Hydrodynamics and transport processes on the historical landscape: geomorphic control of functional complexity and implications for restoration

Bay-Delta Science Conference 2010

Chris Enright

DWR and Delta Science Program

A simple tidal ecosystem restoration conceptual model:

Tidal restoration provides ecosystem function support: food, refuge, ontogeny, subsidies

Depends on:

residence time

structural complexity/ relationships

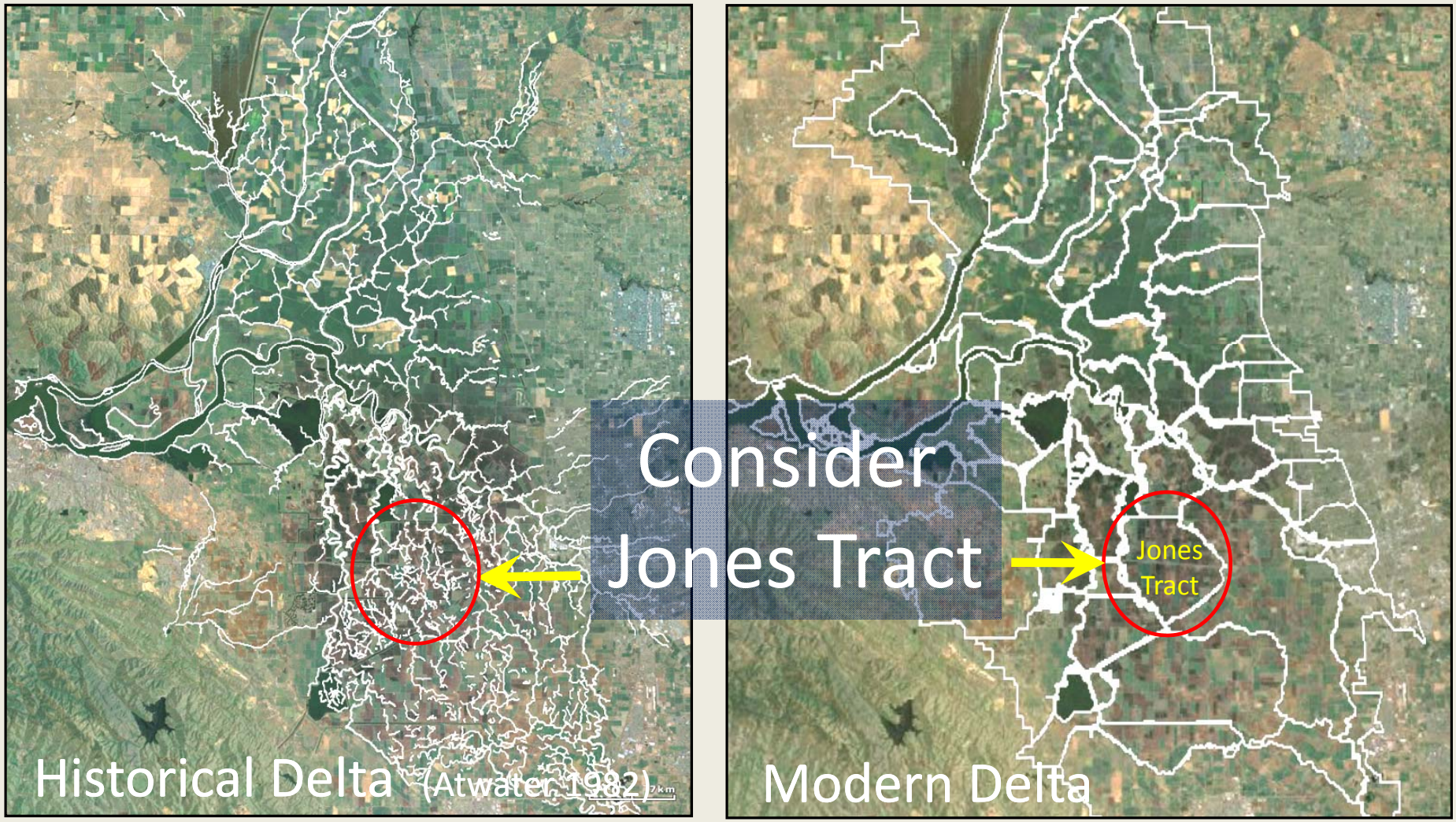
physical and scalar gradients

habitat connectivity

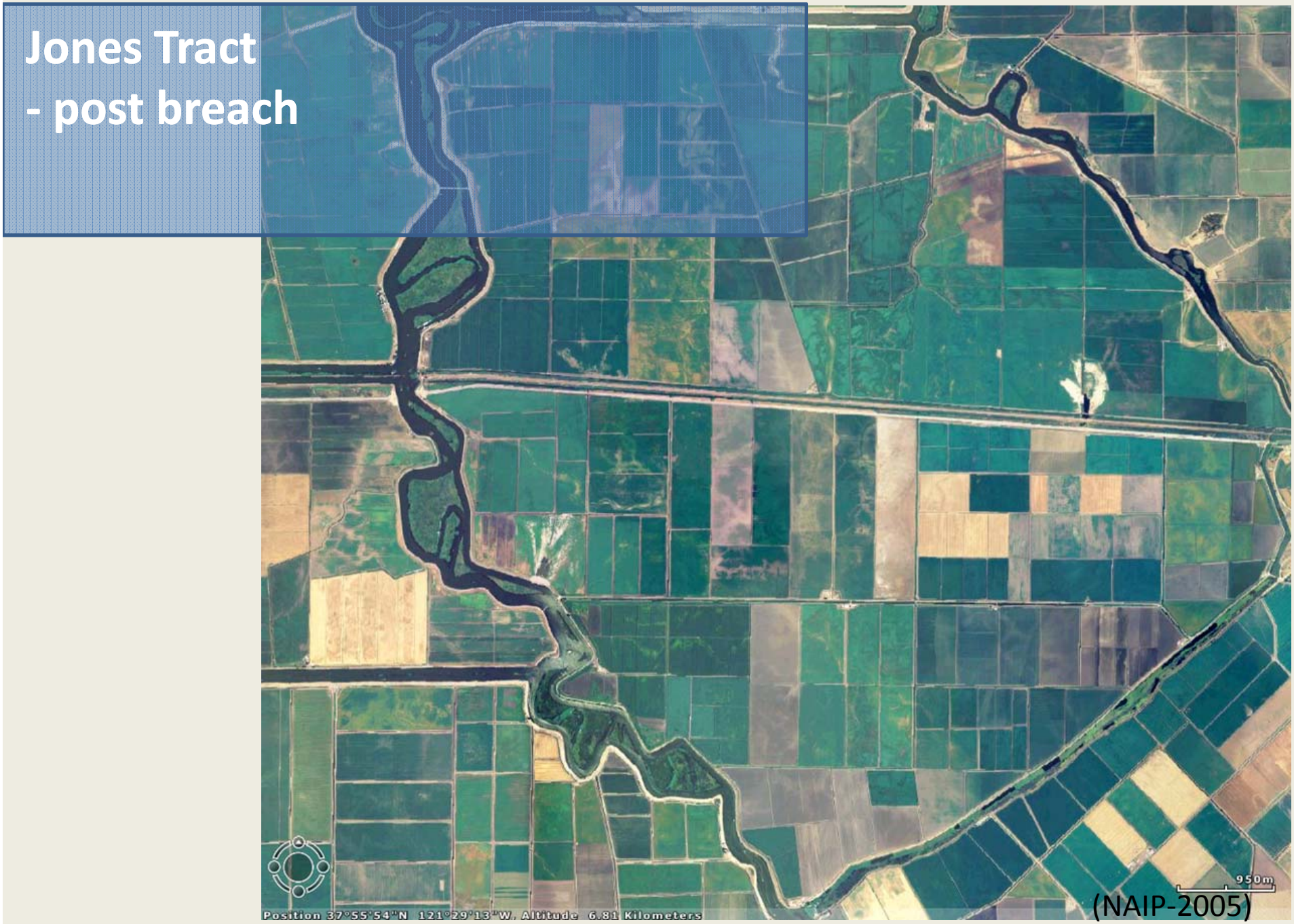
This talk

1. Compare historical and modern Delta: To fish, the delta was both bigger *and* smaller.
2. Historical Delta was spatially gradient rich: *landscape configuration and functional outcomes*

1. To a mobile organism, the historical Delta was both *bigger*, *and* ***smaller***

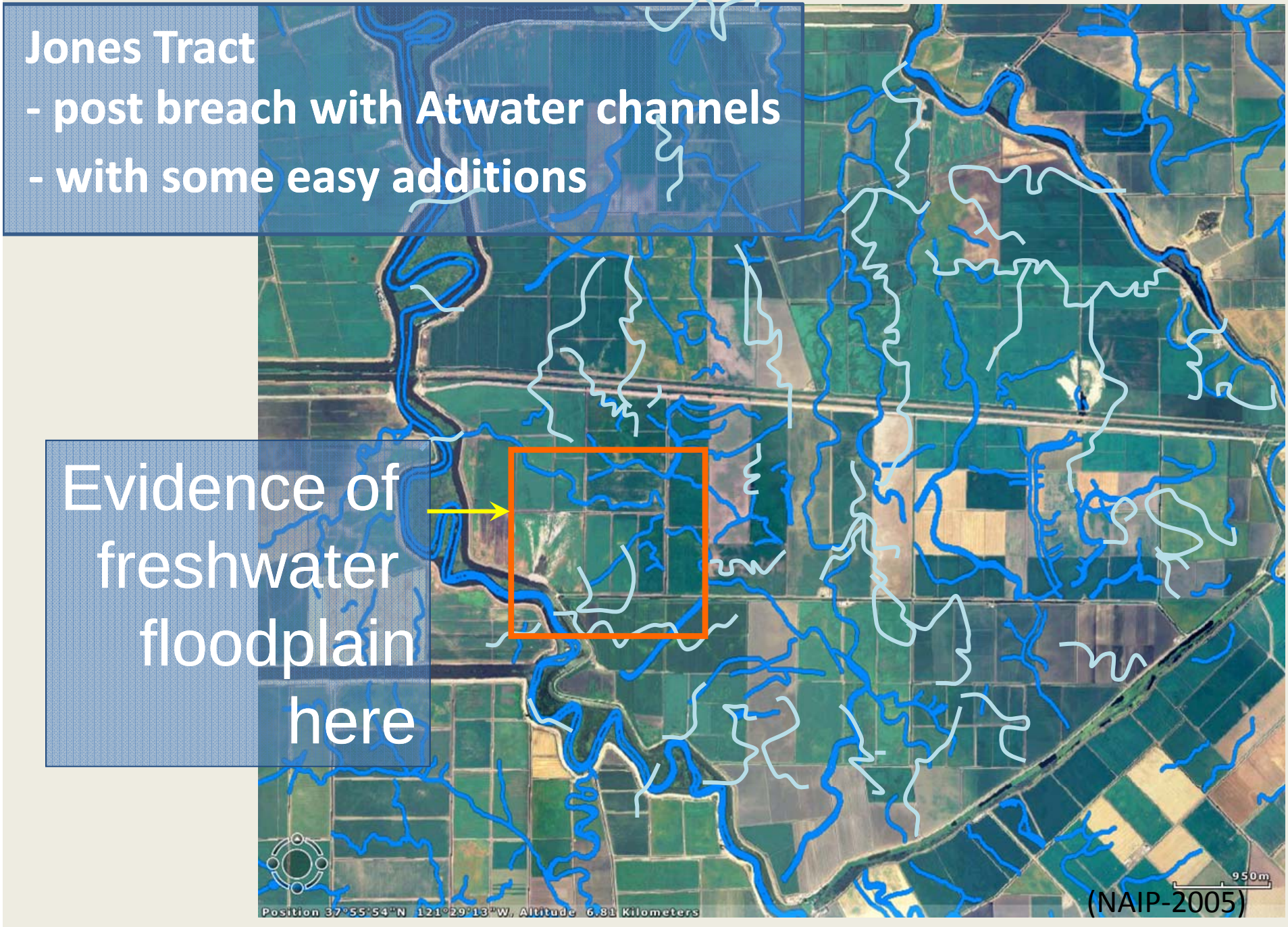


1. Historical Delta was bigger *and* smaller



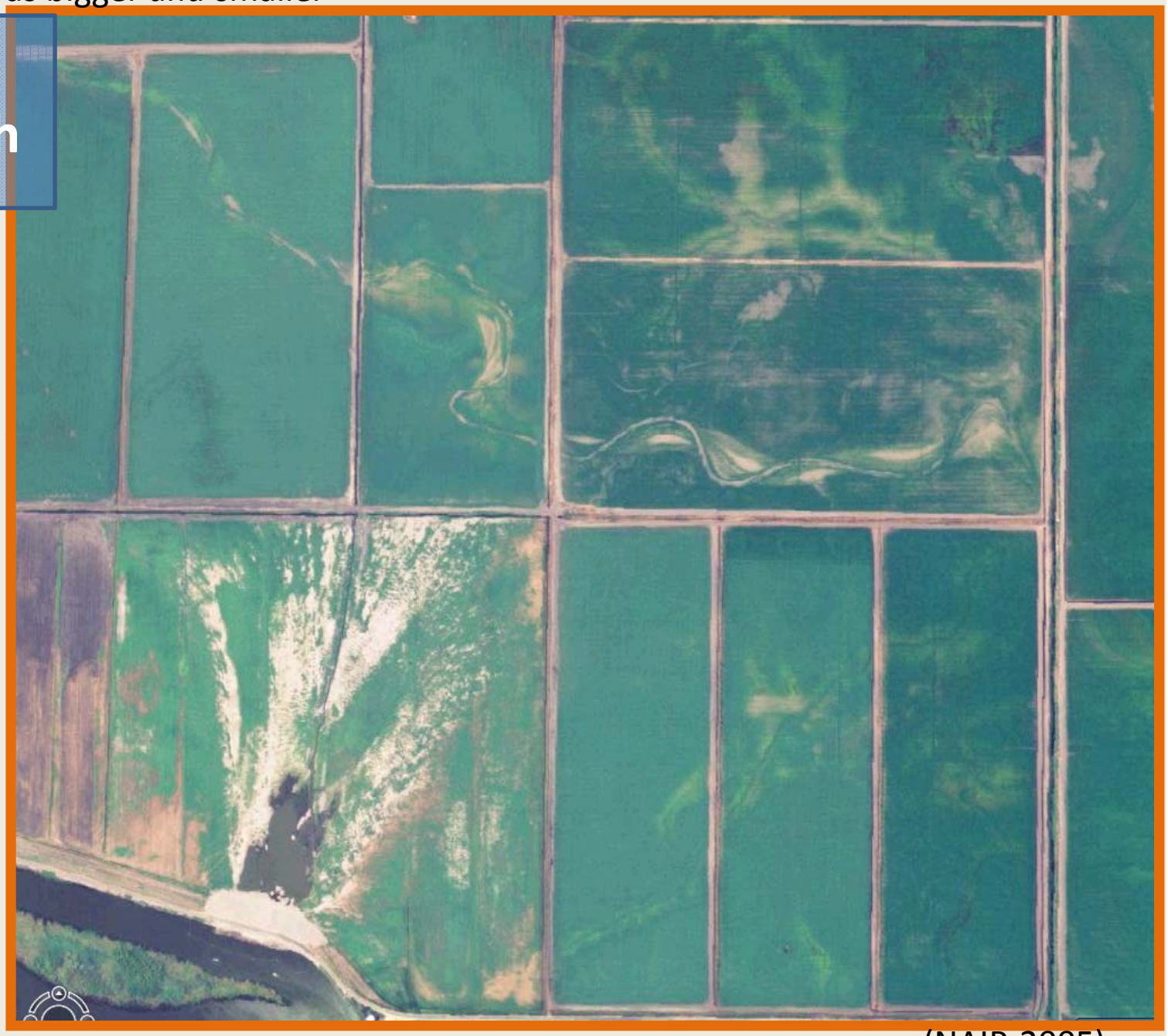
(NAIP-2005)

1. Historical Delta was bigger *and* smaller



1. Historical Delta was bigger *and* smaller

Jones Tract - post breach

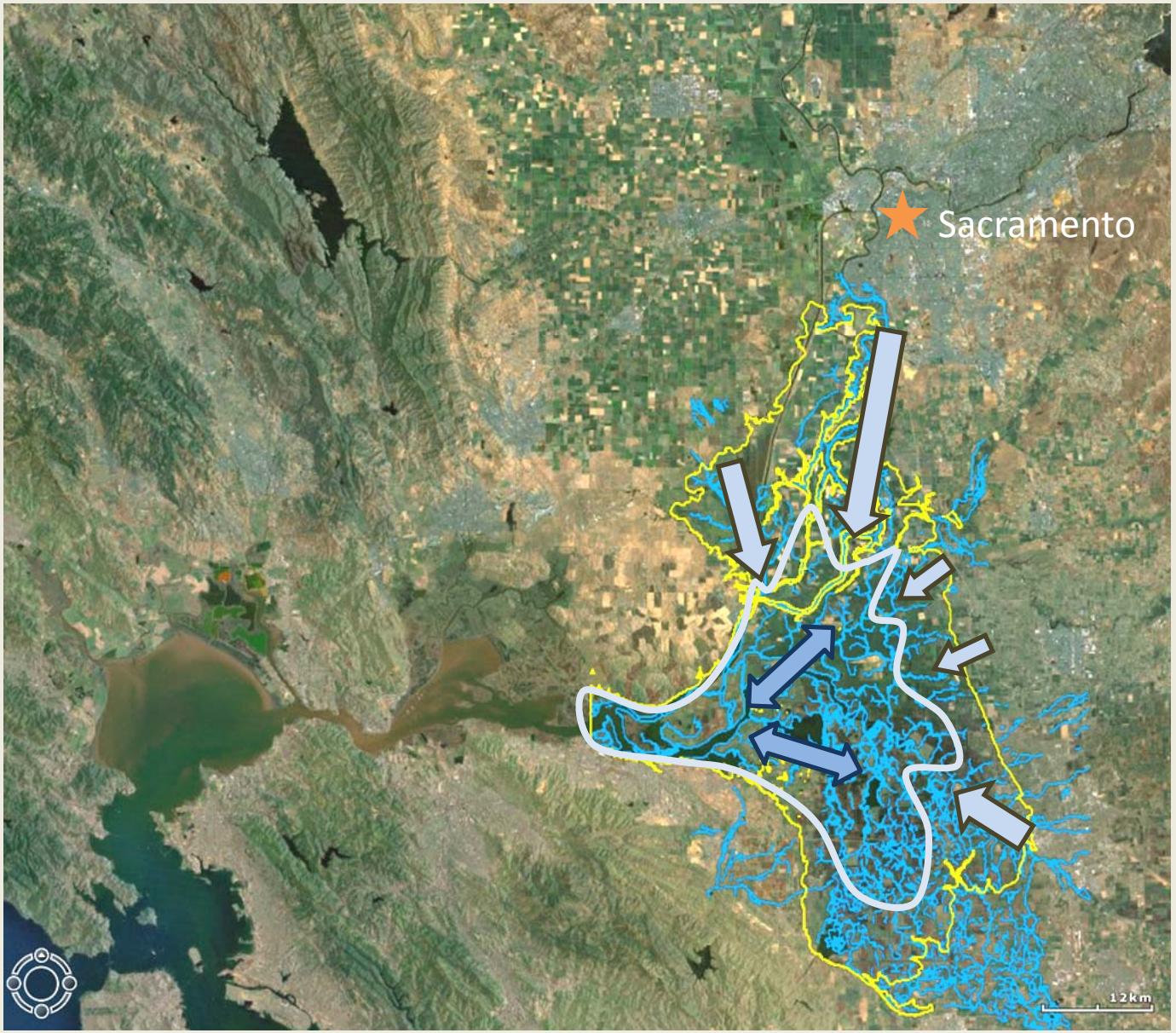


(NAIP-2005)

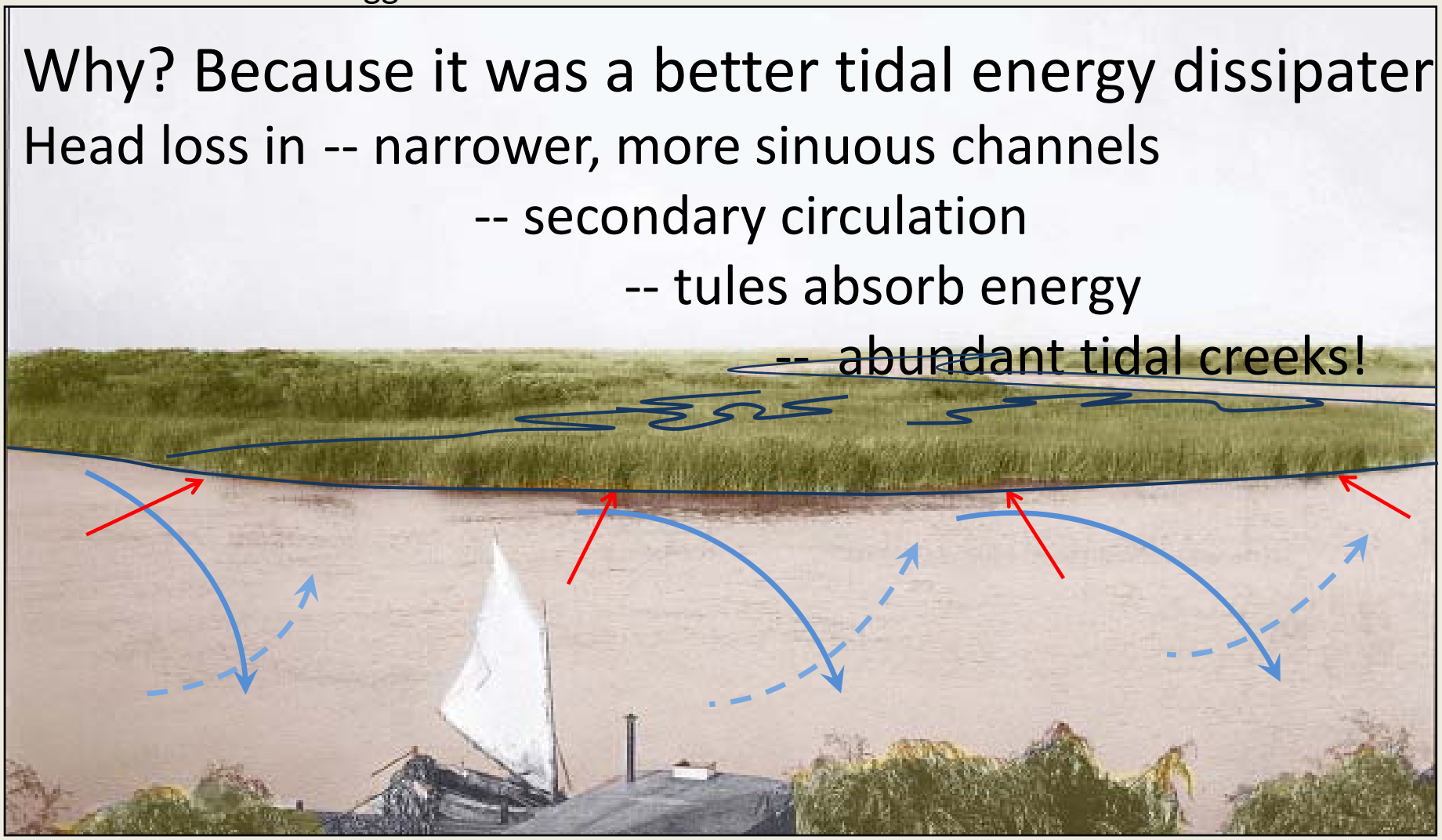
1. Historical Delta was bigger *and* smaller

Historically, the tidal Delta scaled differently: bigger and smaller

Extent of bi-directional tide may have been smaller



1. Historical Delta was bigger *and* smaller



"A view of delta in natural wetland state
covered with tules unsuitable for farming."

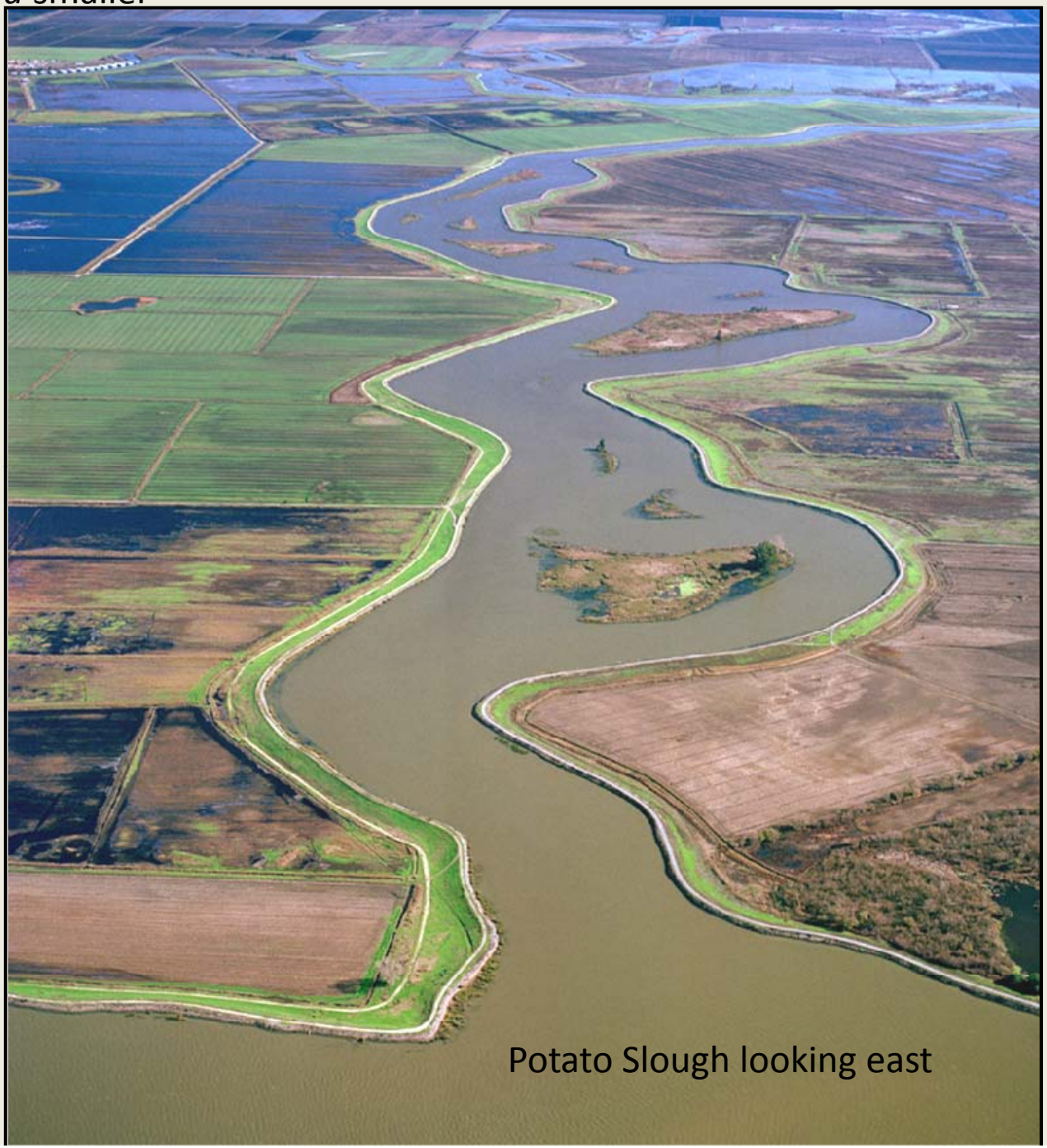
From: "DOWN RIVER; Sacramento to the Golden Gate
A Pictorial Record:1840-1940"
(No date on the photo)

2. Historical Delta was bigger *and* smaller

Modern Delta: Far less energy dissipation.

"a canal system"

THE STATE OF BAY-DELTA SCIENCE 2008



Potato Slough looking east

Historical tidal channels were narrow and long, while modern delta is wide and short (A to B)

- Modern levees set back
- Meanders cut off

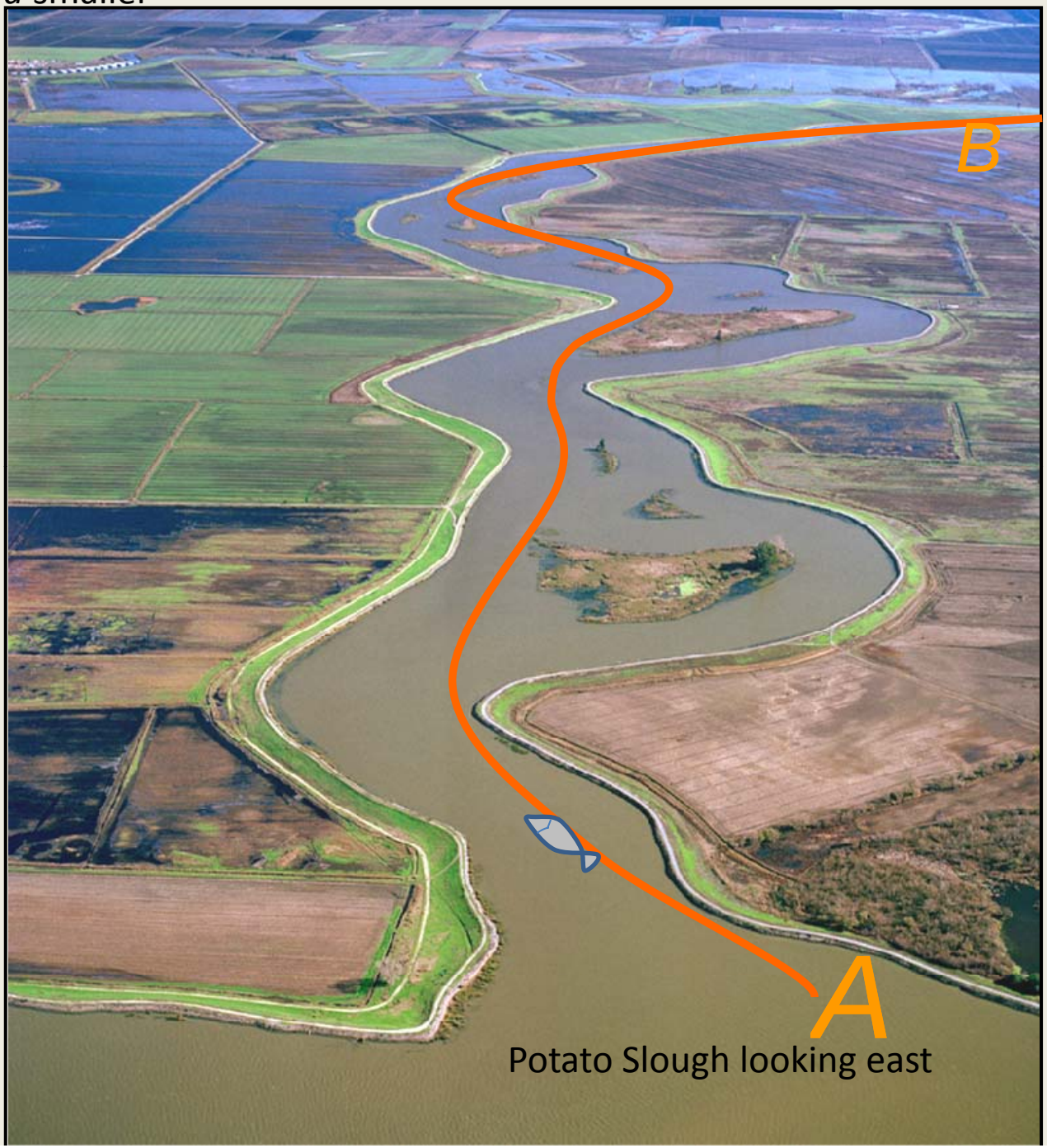
2. Historical Delta was bigger *and* smaller

Historically, tributaries were separate systems; Modern Delta is a short circuit

1. Historical Delta was bigger *and* smaller

Modern Delta is wide and short– a straight shot for fish…

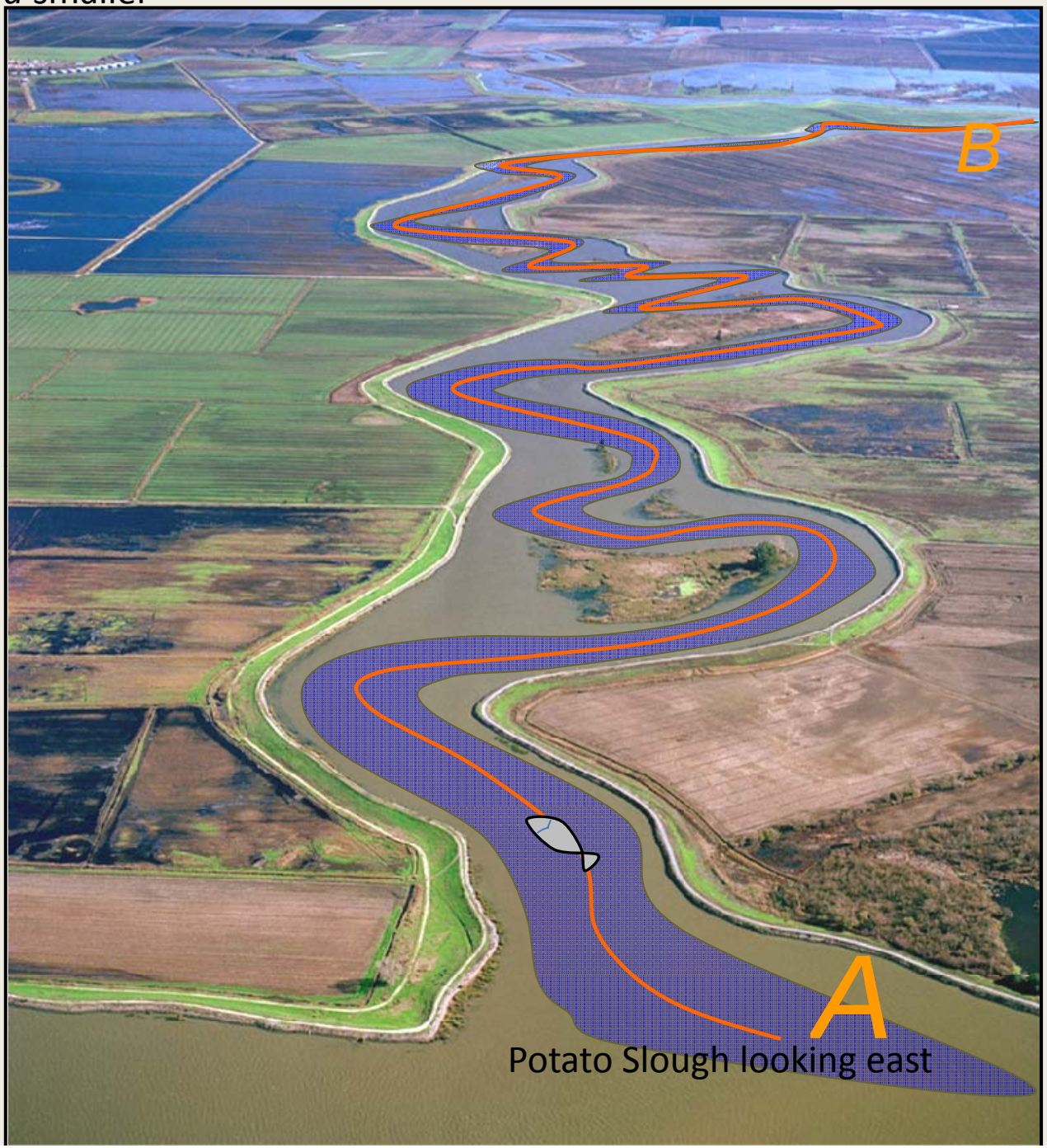
THE STATE OF BAY-DELTA SCIENCE 2008



1. Historical Delta was bigger *and* smaller

Historical Delta was narrower and longer

THE STATE OF BAY-DELTA SCIENCE 2008



1. Historical Delta was bigger *and* smaller

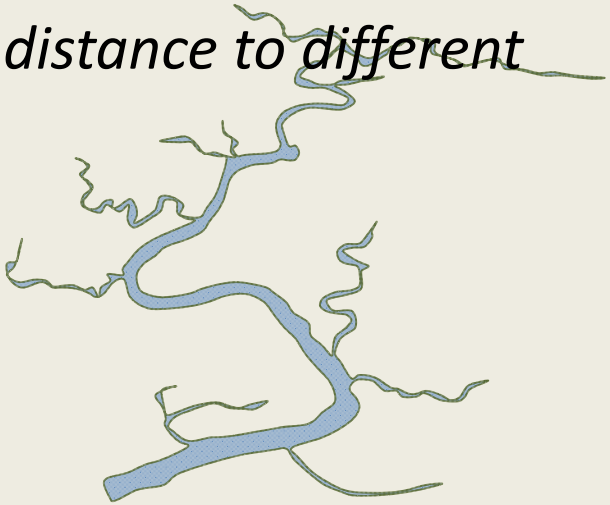
Historical Delta is bigger *and* smaller

Historical Delta "bigger"

- Long sinuous channels
- Greater channel/area ratio
- Waaaay more "edge"
- Long geographical distances A to B

Historical Delta "smaller"

- ↓ geographical tidal extent
- Narrower channels
- ↓ area of bi-directional tide
- Smaller tidal excursion/range
- River influence penetrated
- *shorter distance to different*



2. Delta was spatially gradient rich:

landscape configuration and functional outcomes.

Landscape ecology

How do spatial relationships affect ecological outcomes?

"Outcomes of building new habitats will depend upon the landscape configuration of those habitats and, in particular, how rapidly they exchange water, solutes, and biota with connected habitats." (Cloern 2007)

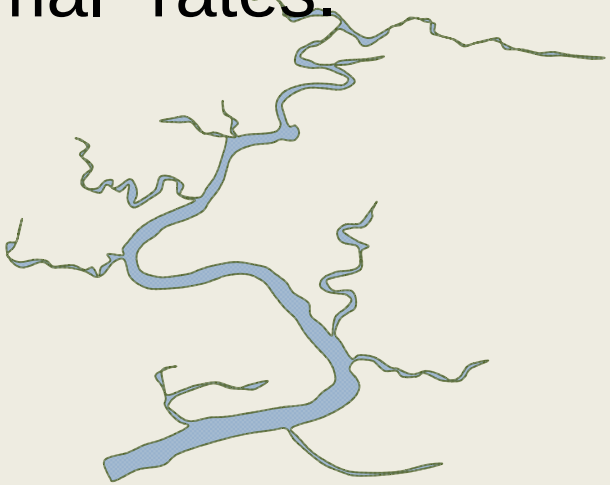
2. Delta was spatially gradient rich:

landscape configuration and functional outcomes.

Basic restoration tension:

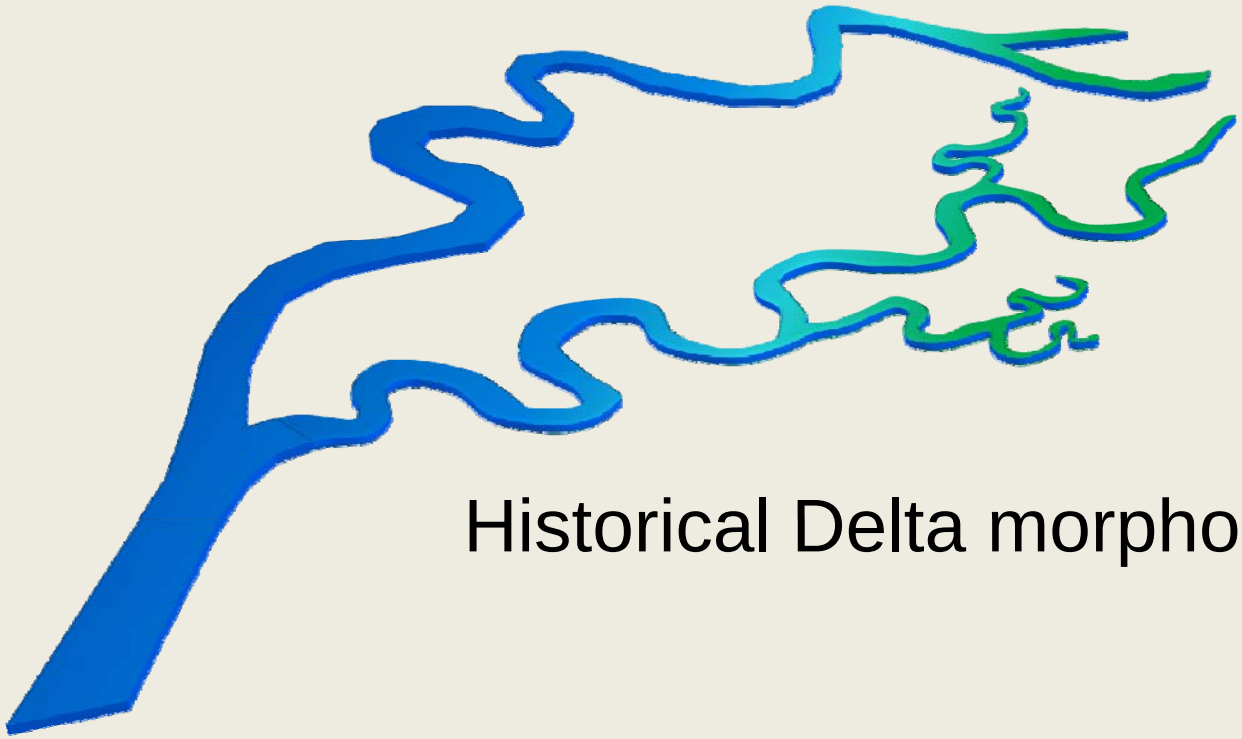
1. restore diverse landscape attributes with differential functional outcomes.

2. Mix water between them at “optimal” rates.



2. Delta was spatially gradient rich

example: *Residence time*



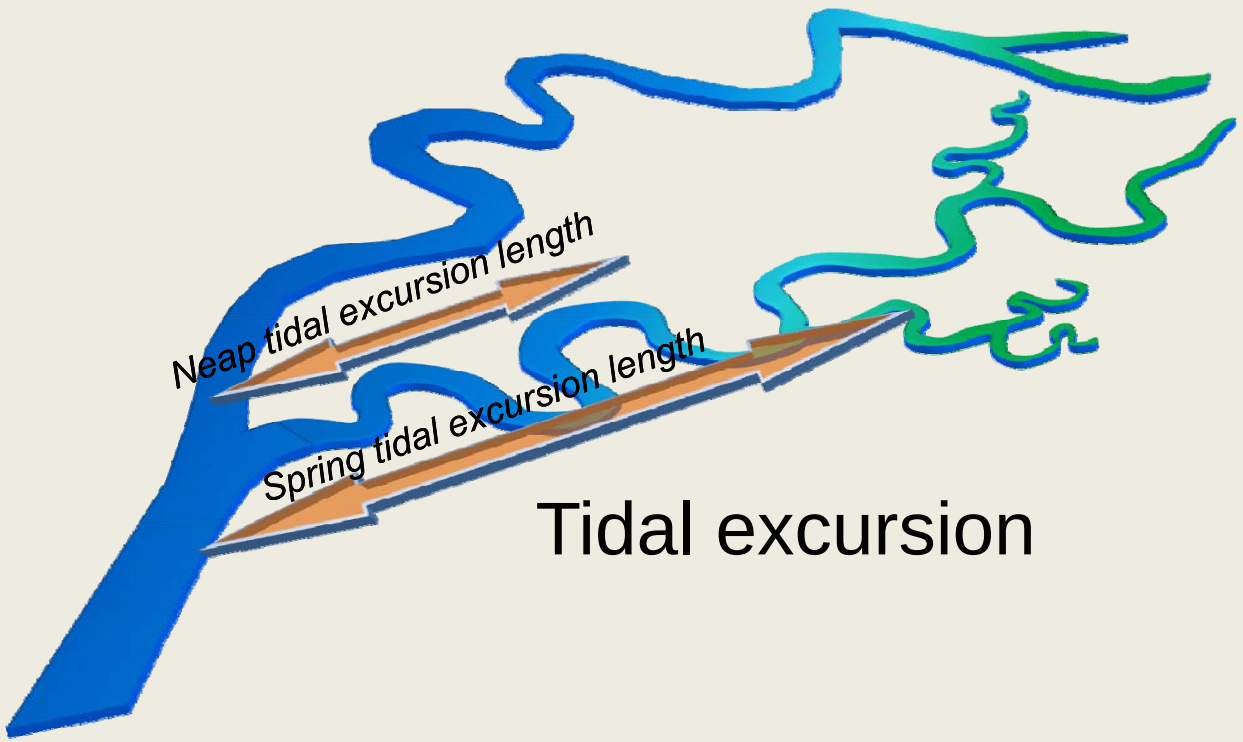
Low order
tidal creeks
(~autotrophic)

Historical Delta morphology

Deep Slough
(~heterotrophic)

2. Delta was spatially gradient rich

example: *Residence time*

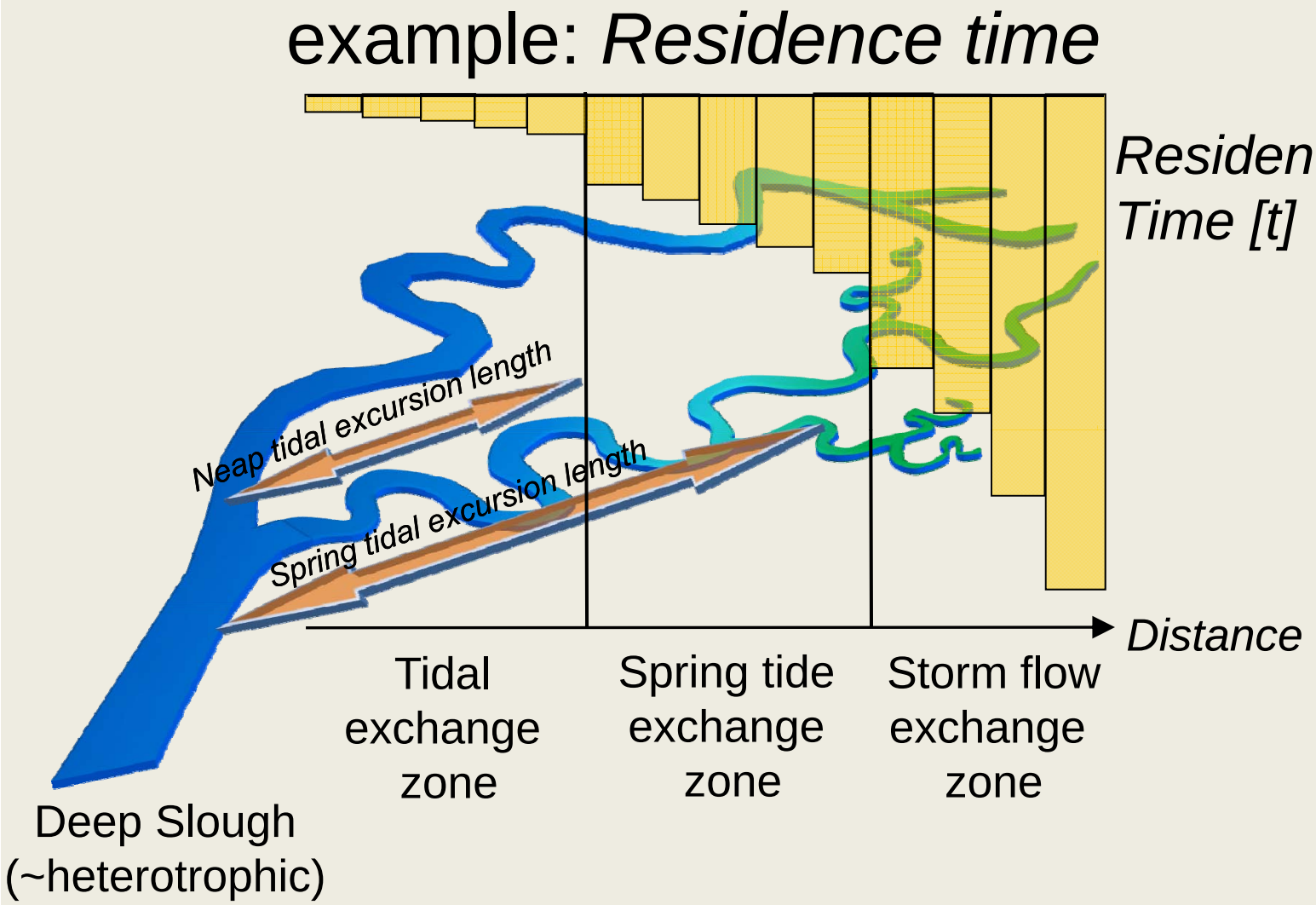


Low order
tidal creeks
(~autotrophic)

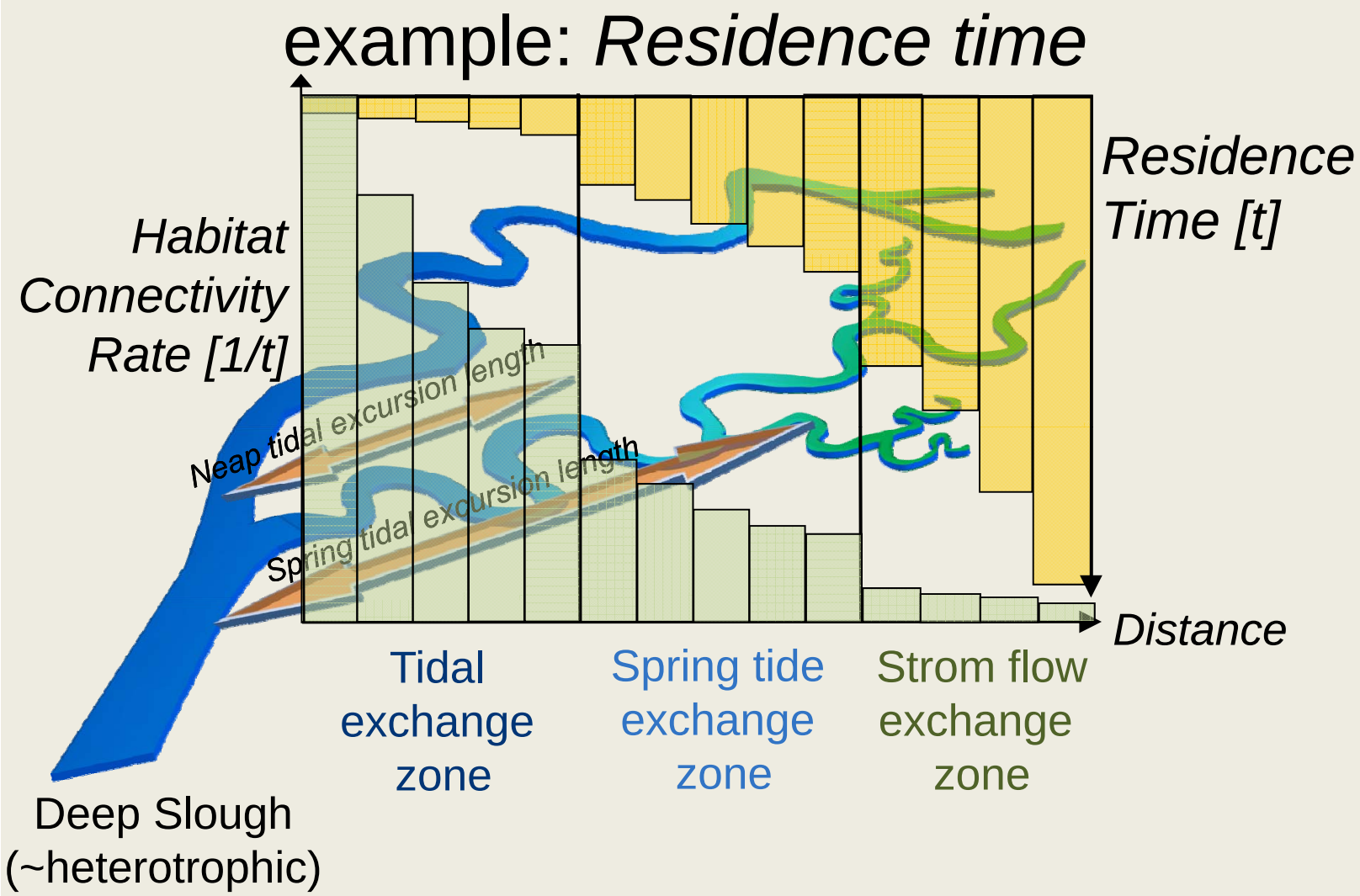
Tidal excursion

Deep Slough
(~heterotrophic)

2. Delta was spatially gradient rich

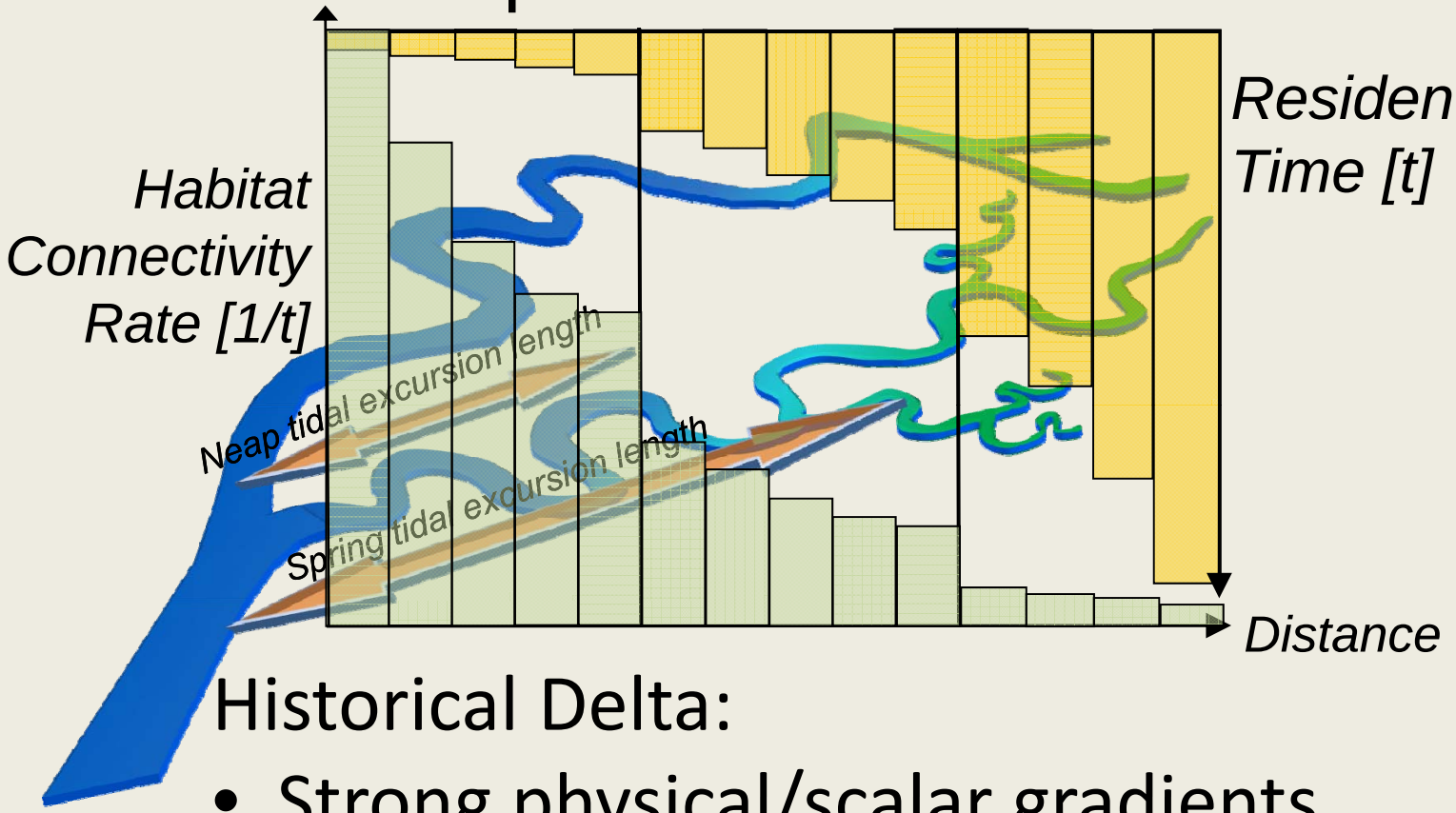


2. Delta was spatially gradient rich



2. Delta was spatially gradient rich

example: *Residence time*

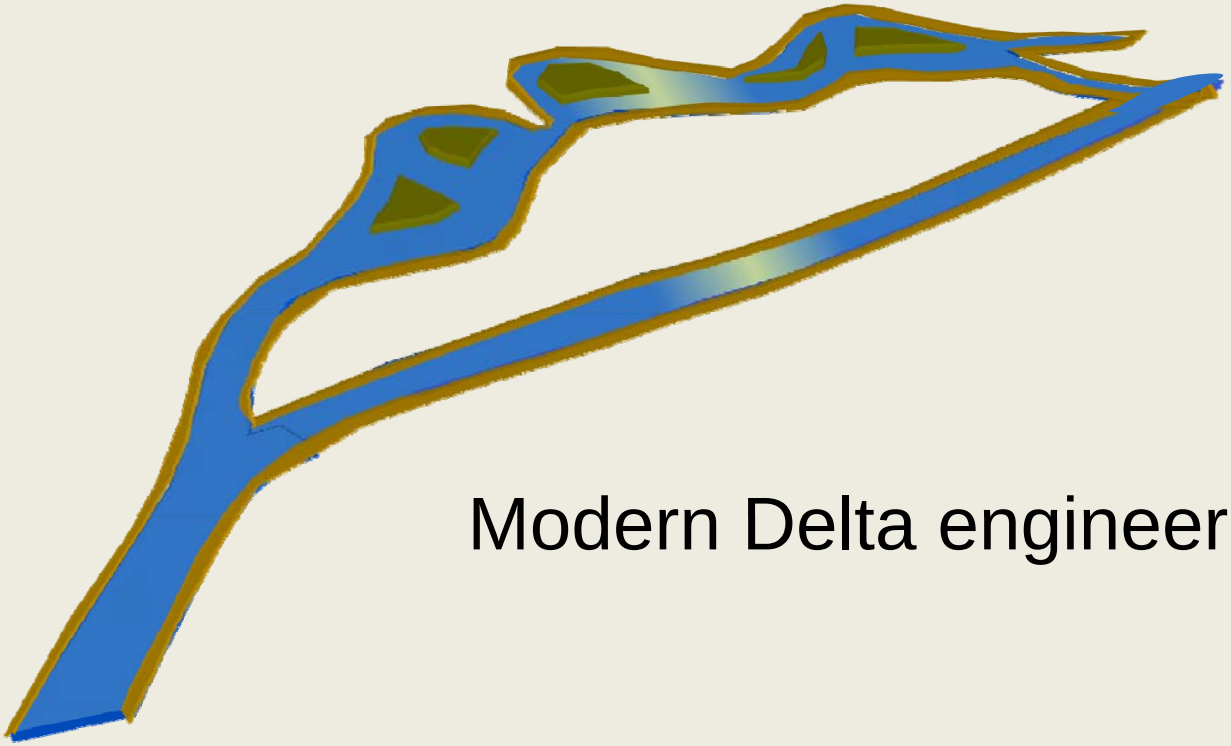


Historical Delta:

- Strong physical/scalar gradients
- Connectivity is **f**(tide strength)
- Large terrestrial connectivity and exchange
- *Distance to different is small*

2. Delta was spatially gradient rich

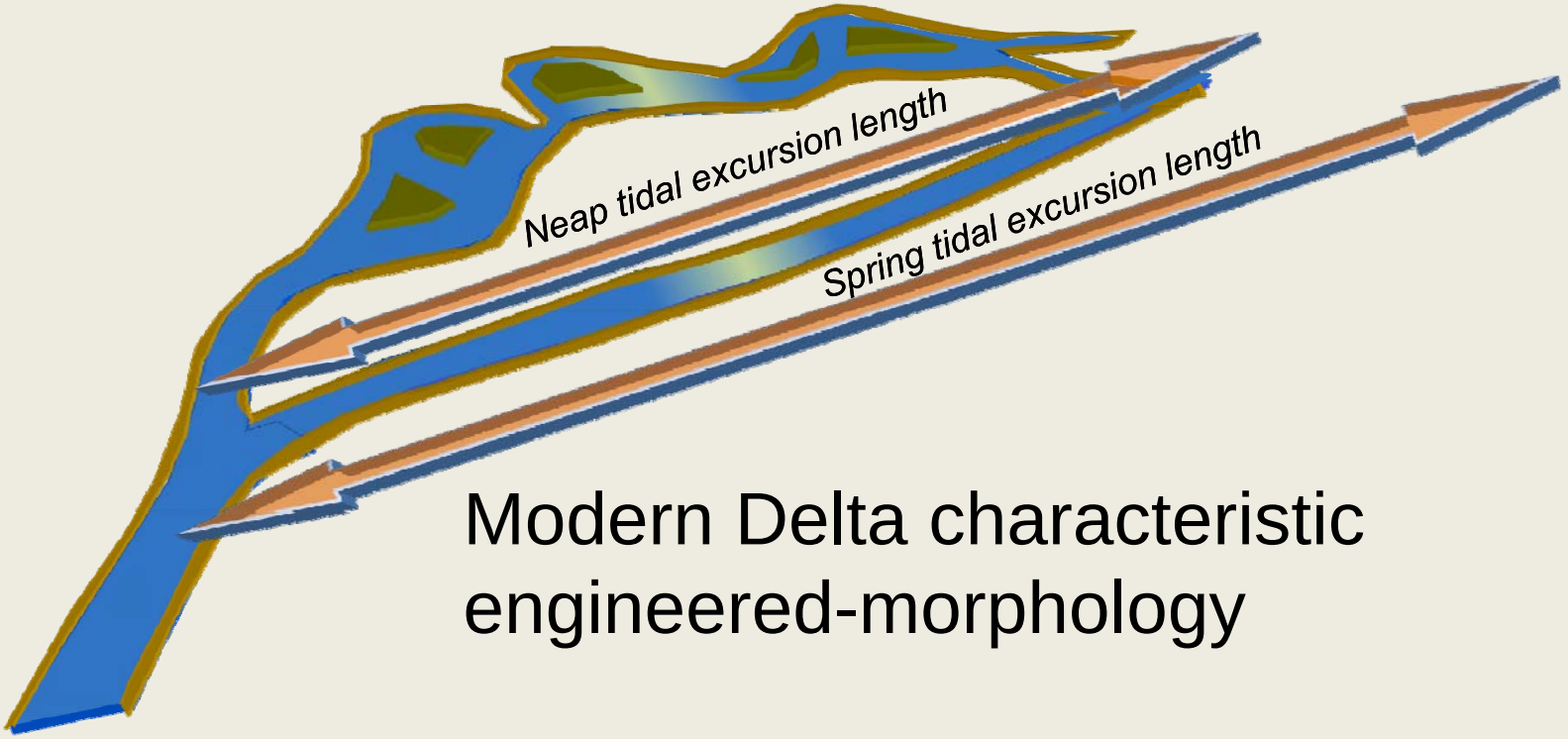
example: *Residence time*



Modern Delta engineered-morphology

2. Delta was spatially gradient rich

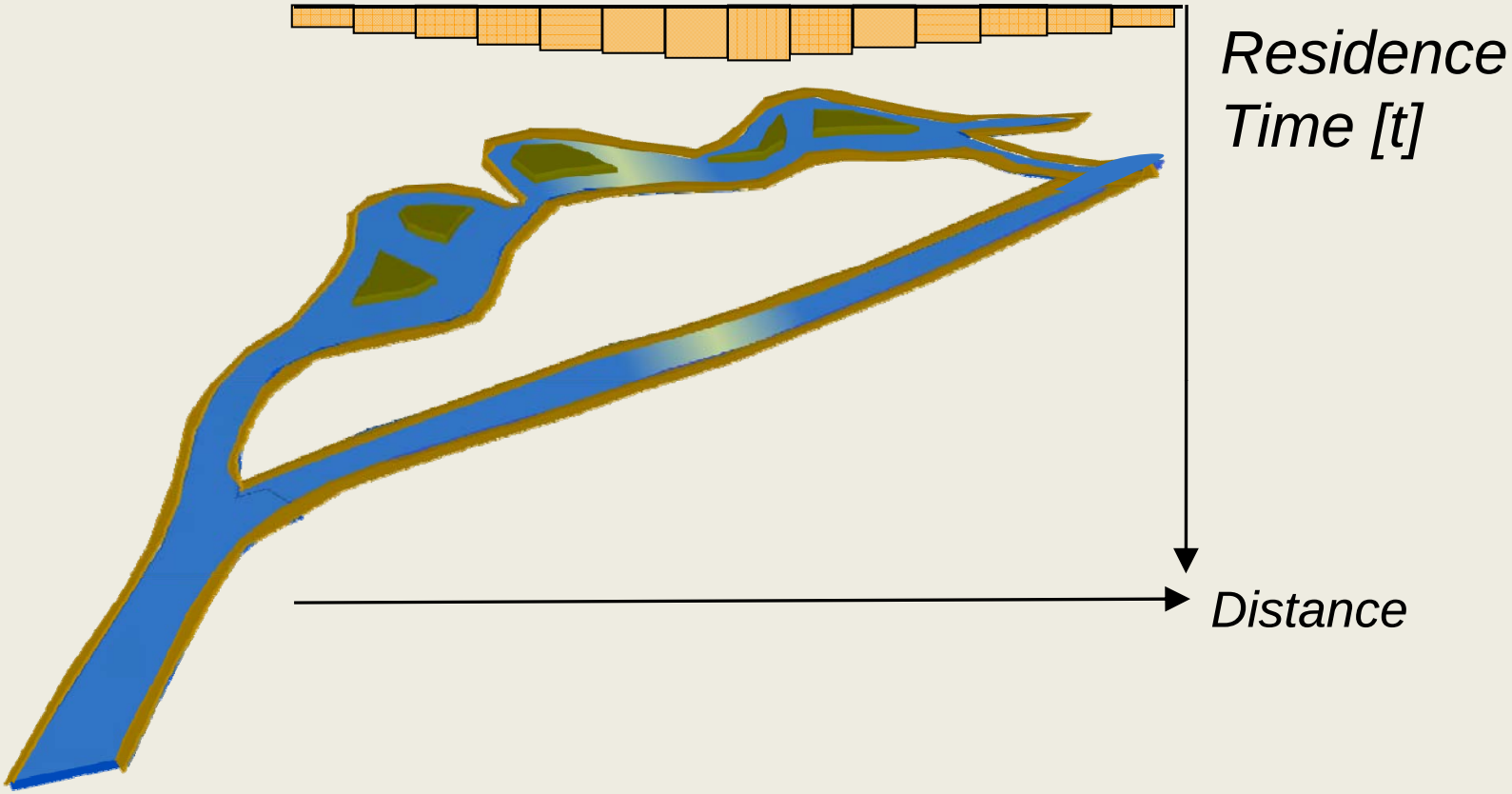
example: *Residence time*



Modern Delta characteristic engineered-morphology

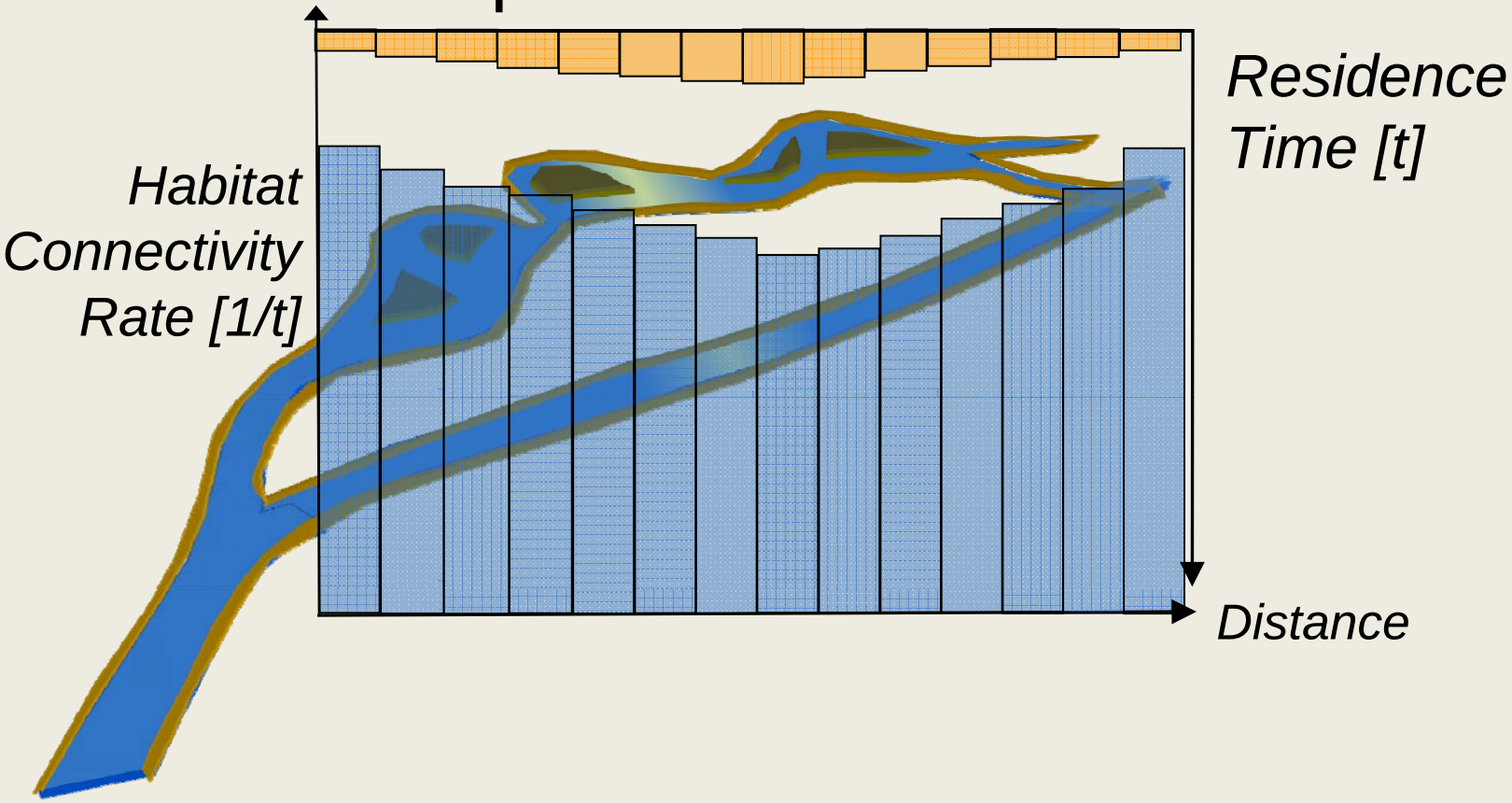
2. Delta was spatially gradient rich

example: *Residence time*



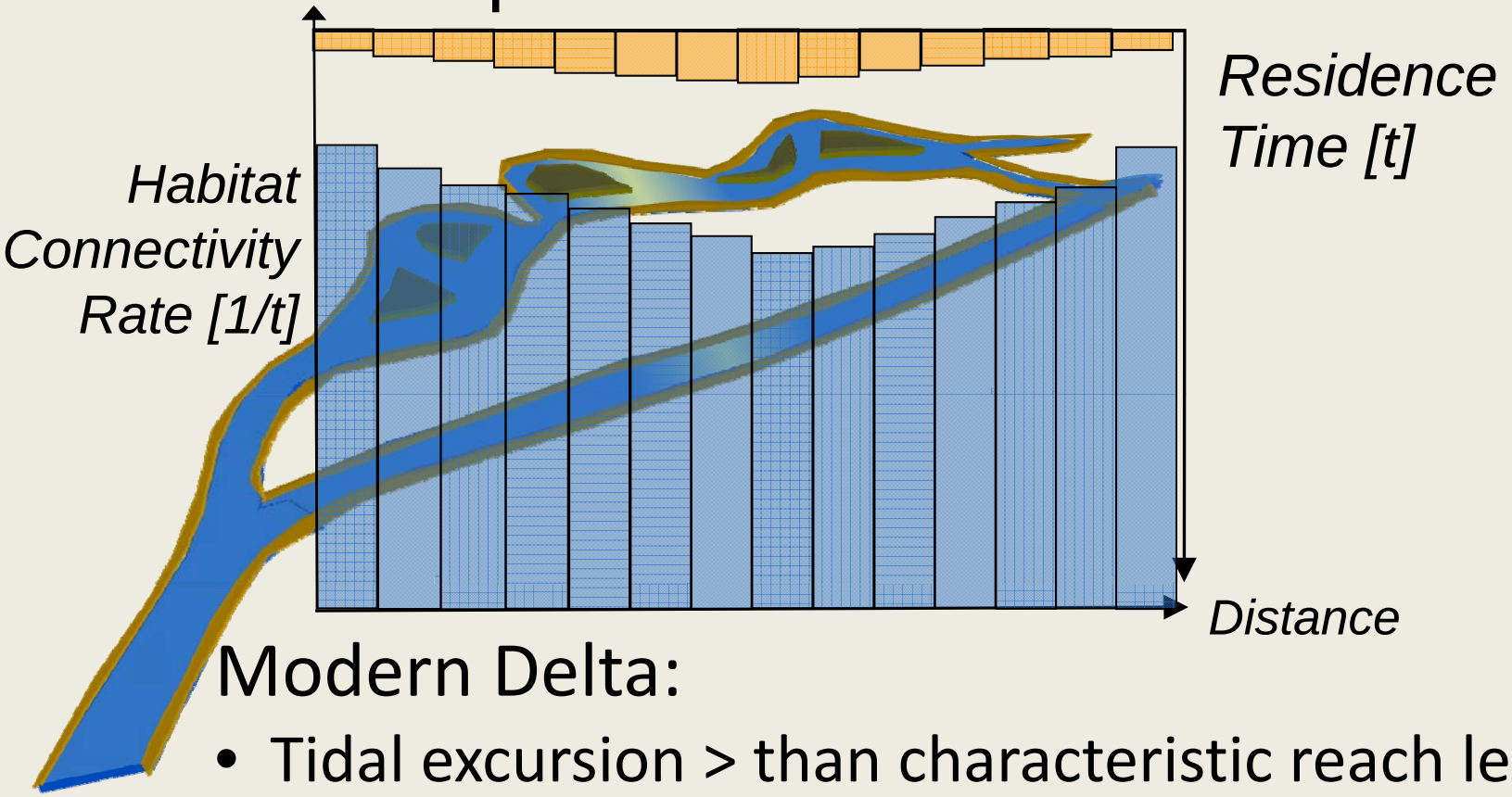
2. Delta was spatially gradient rich

example: *Residence time*



2. Delta was spatially gradient rich

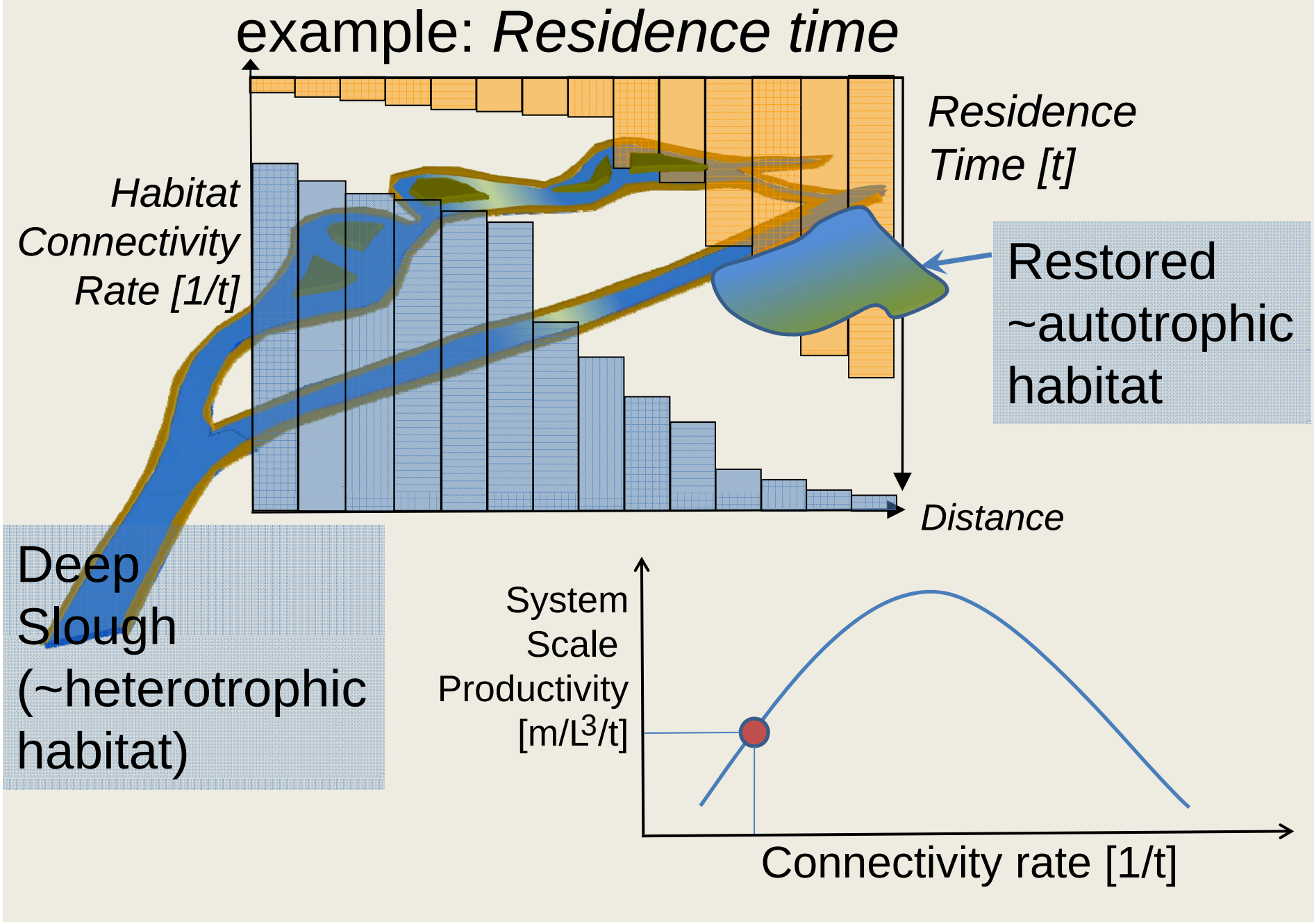
example: *Residence time*



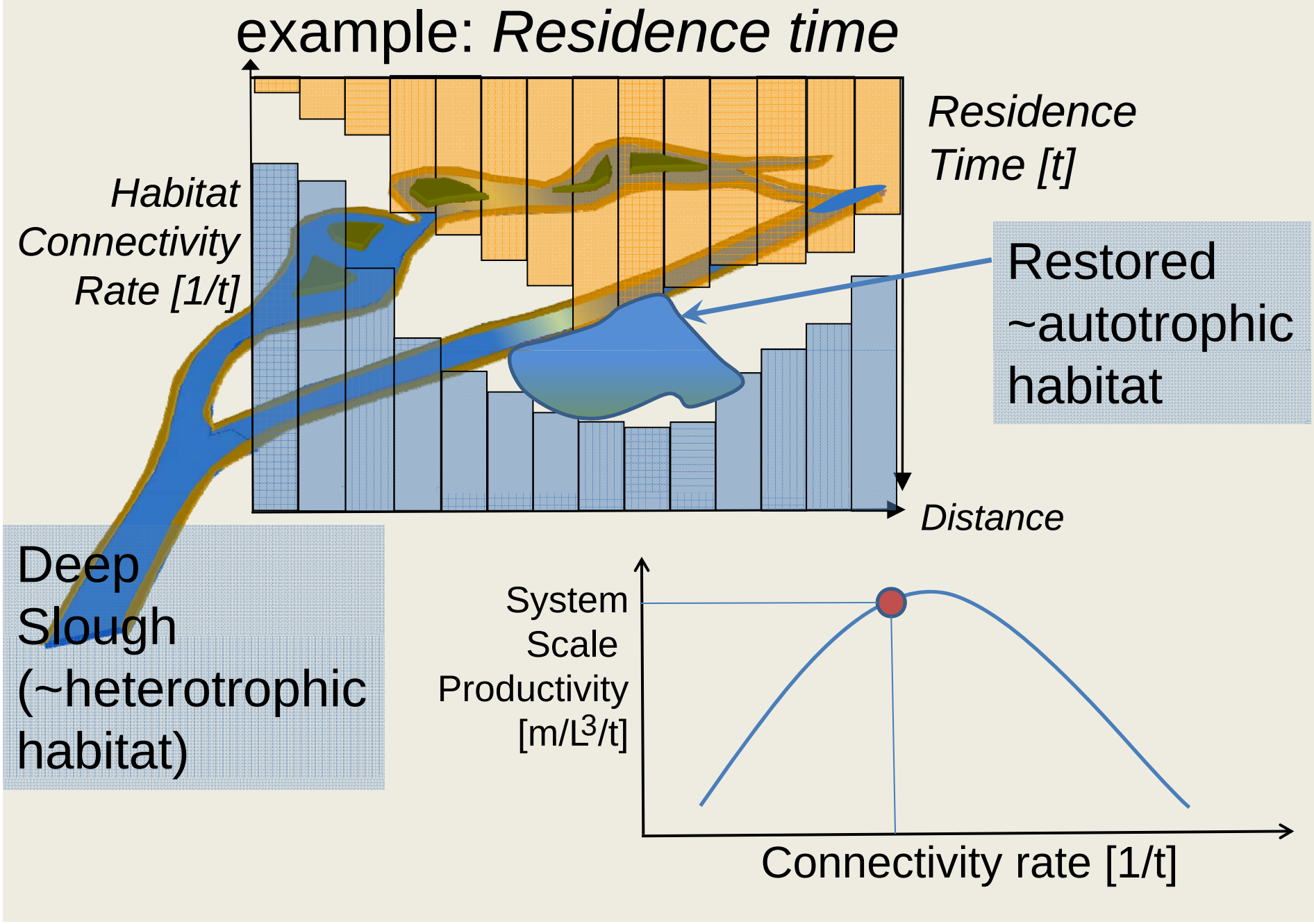
Modern Delta:

- Tidal excursion > than characteristic reach length
- Effectively shorter channel reaches
- Weak longitudinal physical/scalar gradients
- No terrestrial connectivity/exchange
- *Distance-to-different is large*

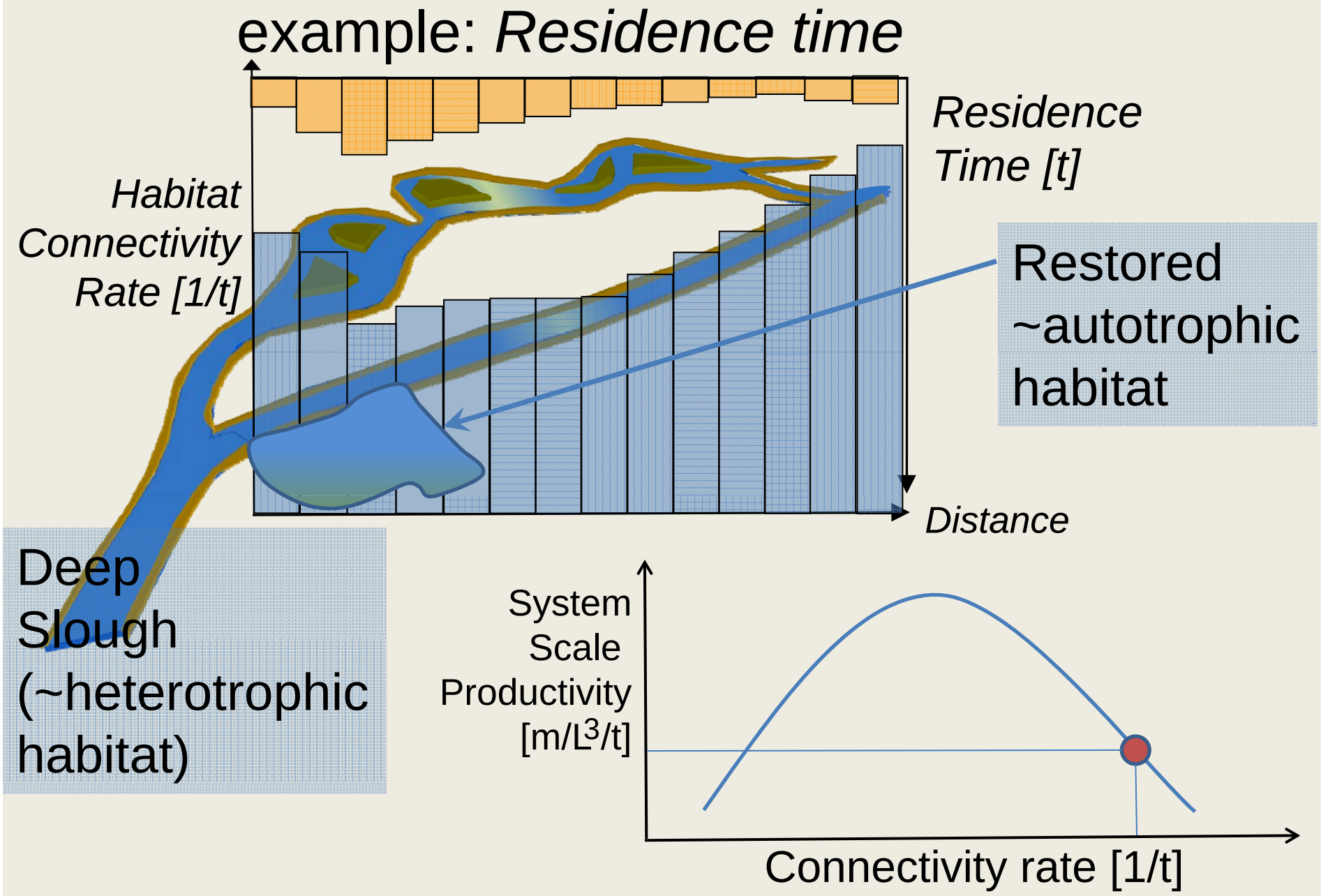
2. Delta was spatially gradient rich



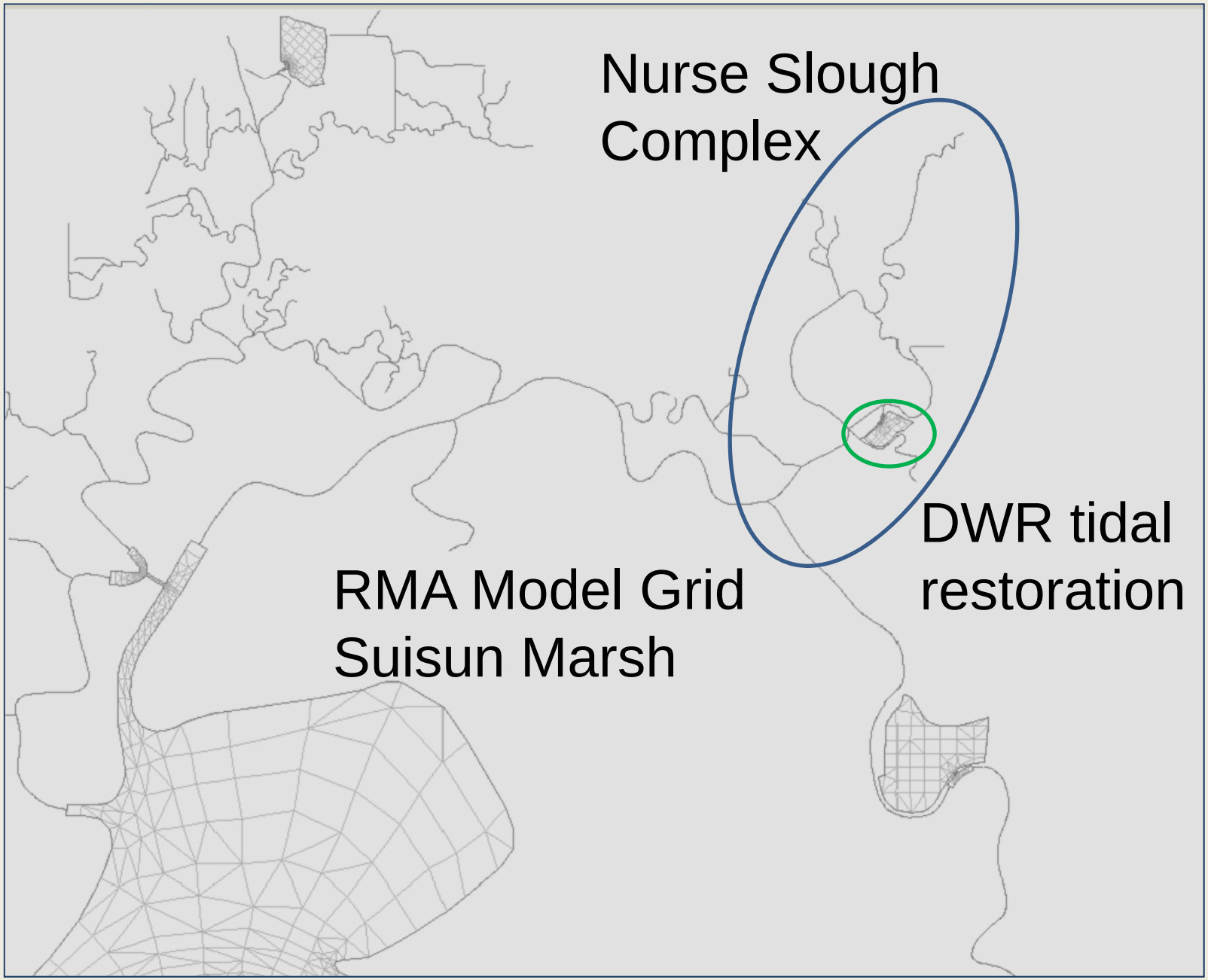
2. Delta was spatially gradient rich



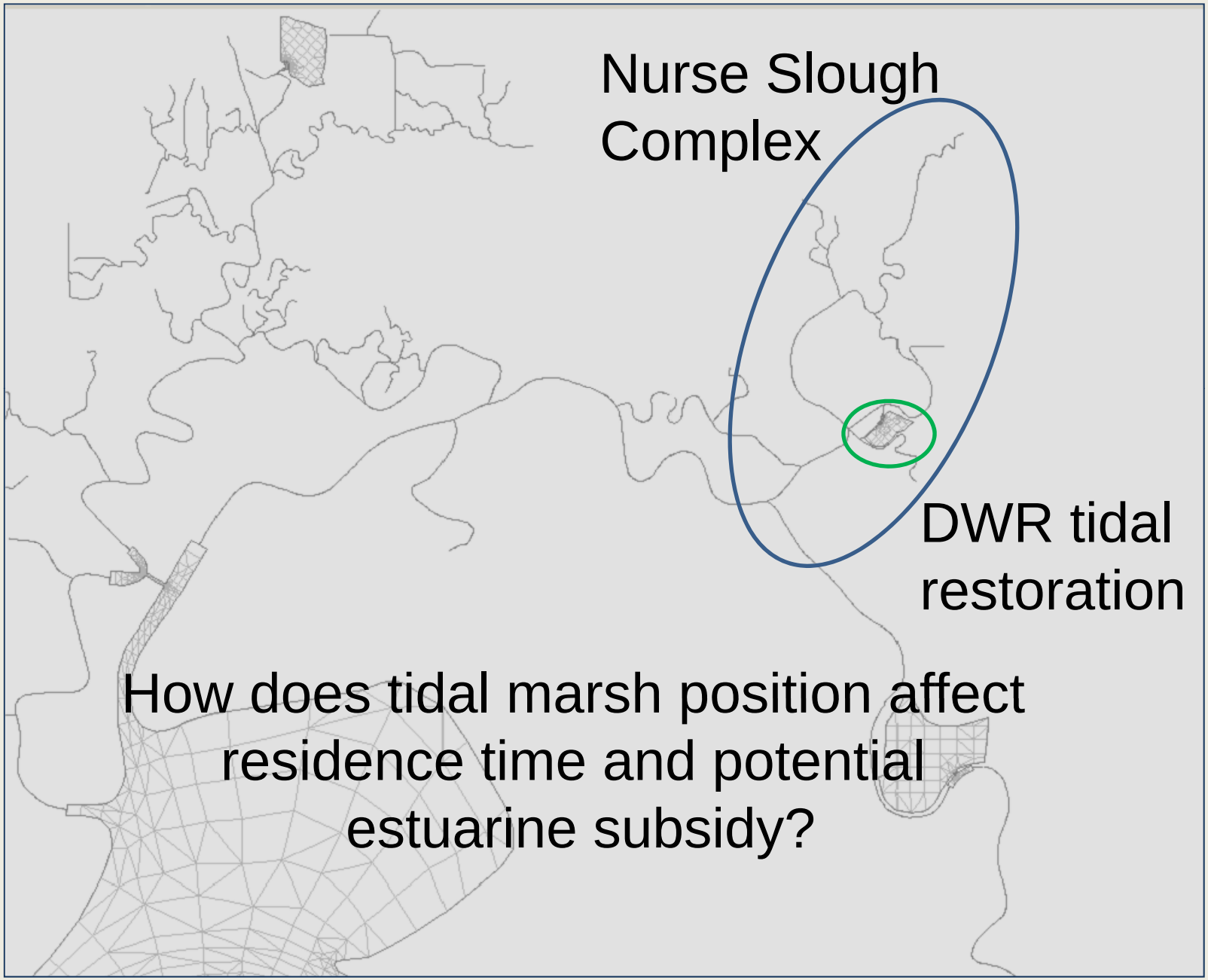
2. Delta was spatially gradient rich



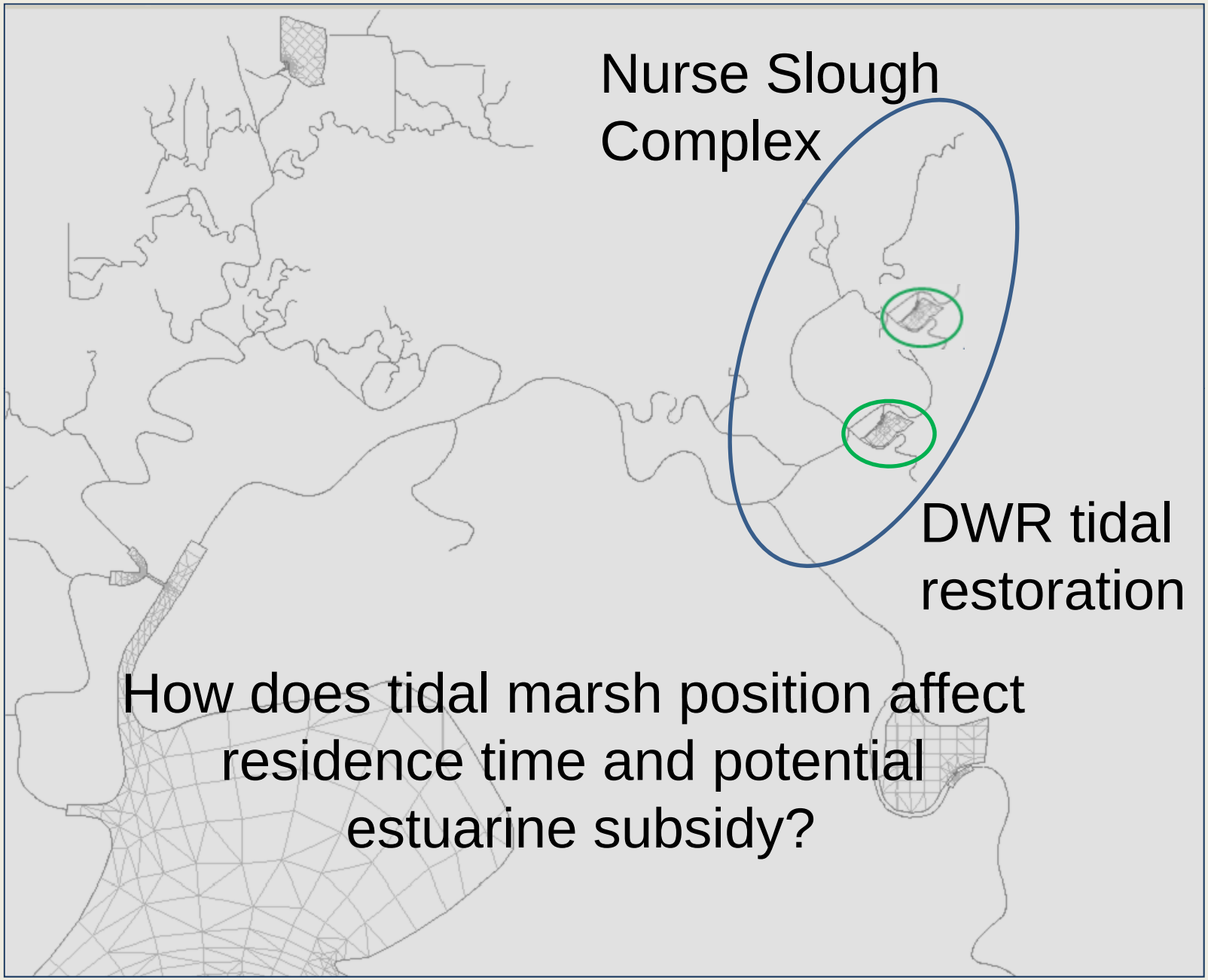
2. Delta was spatially gradient rich– Modeling residence time



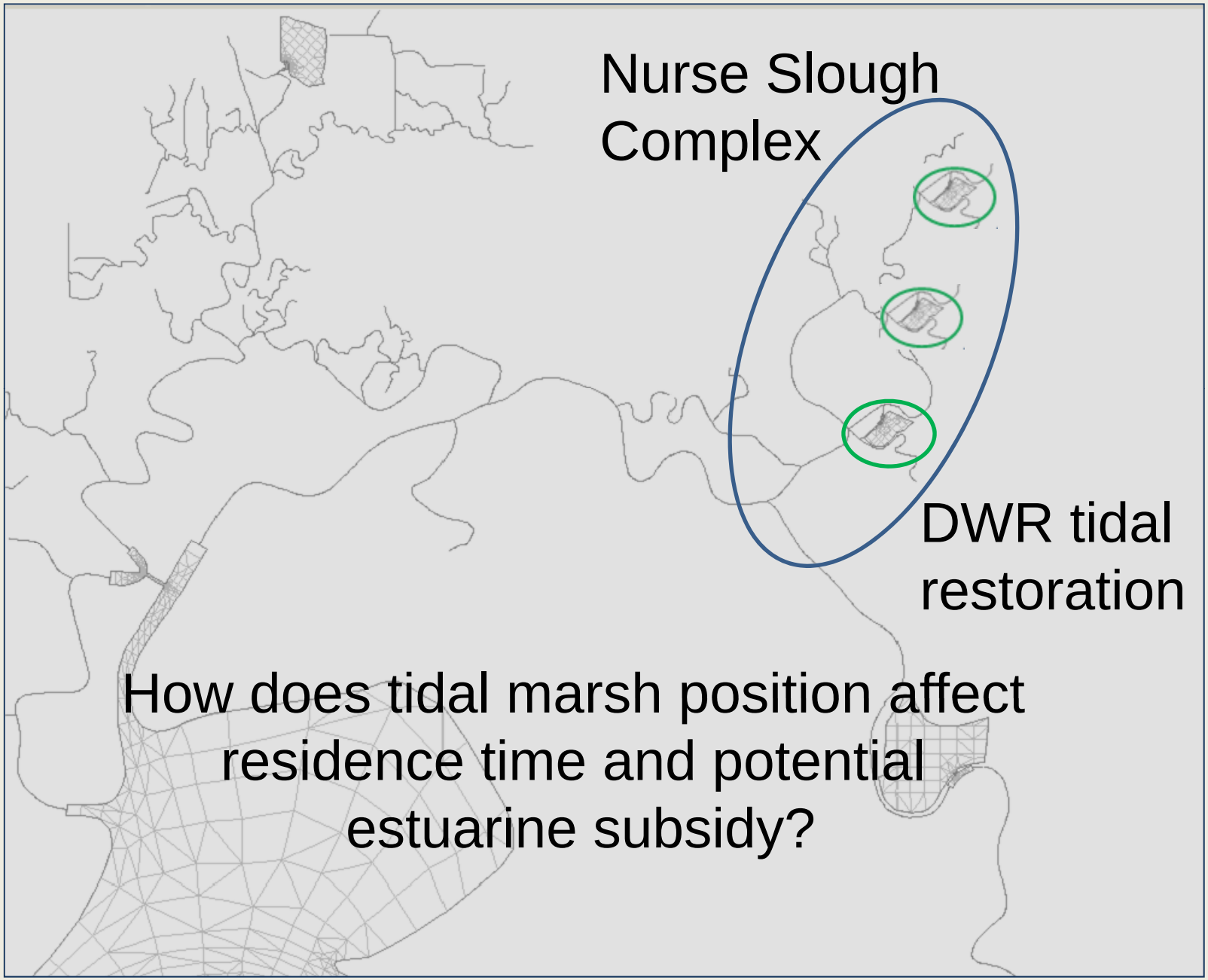
2. Delta was spatially gradient rich– Modeling residence time



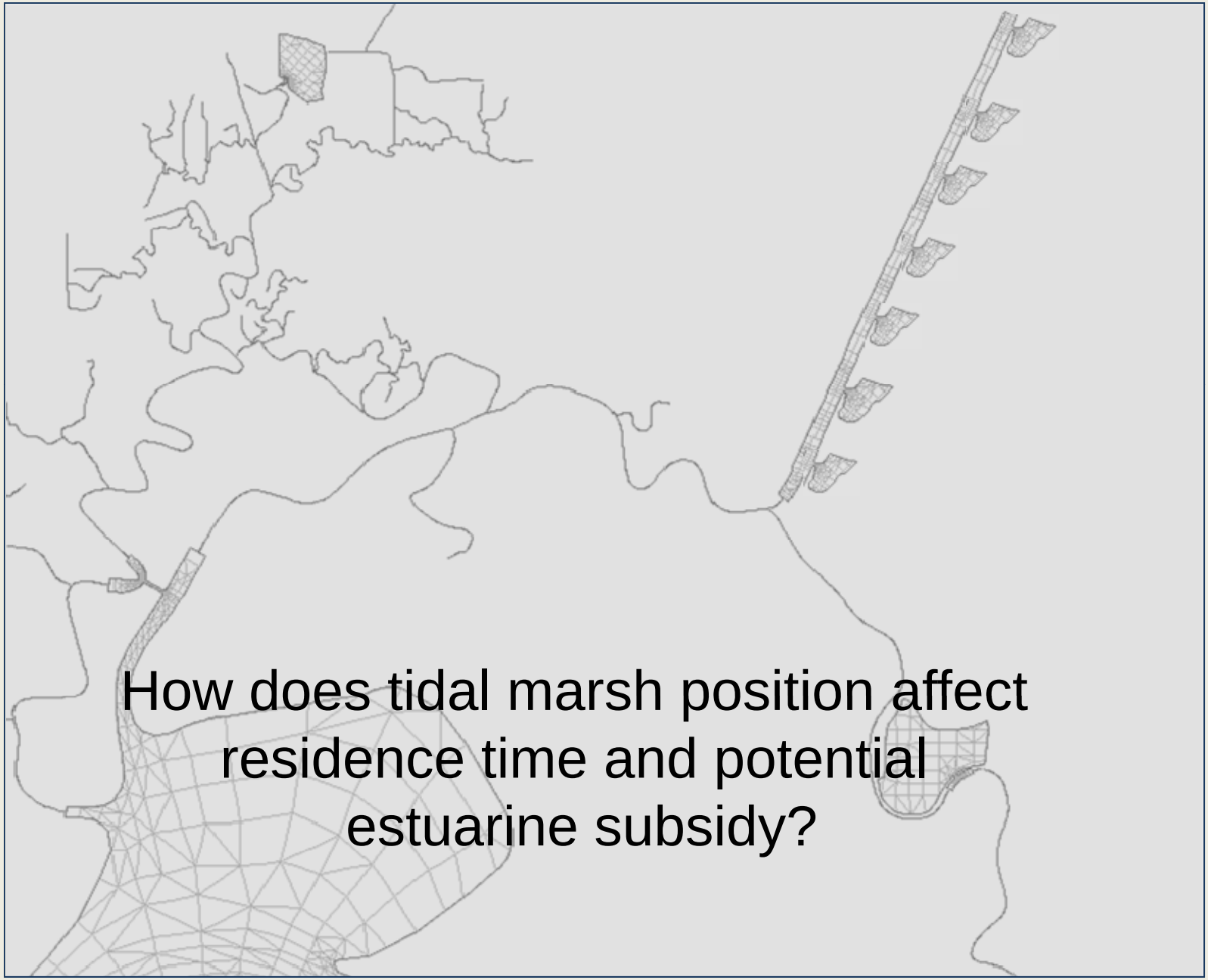
2. Delta was spatially gradient rich– Modeling residence time



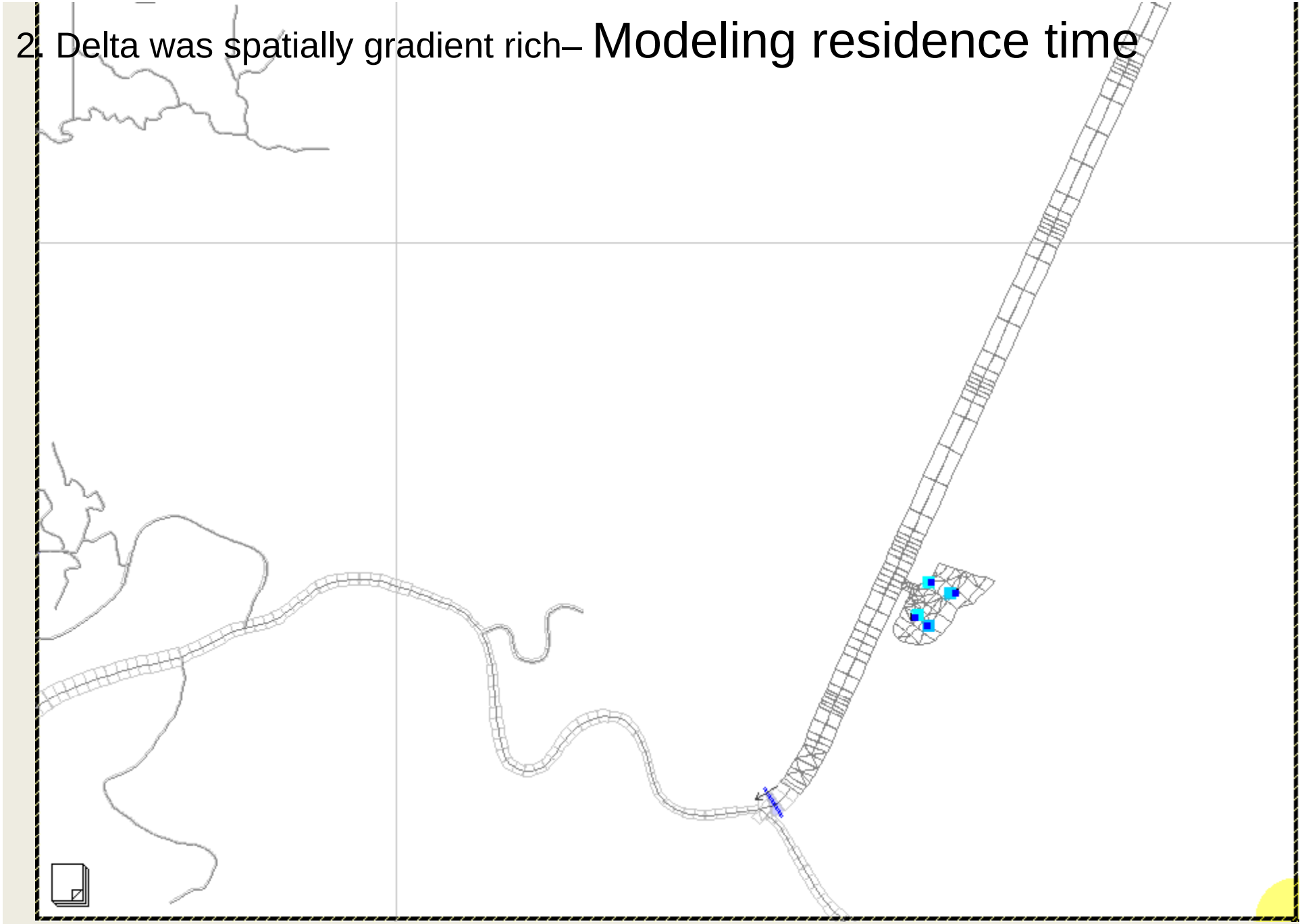
2. Delta was spatially gradient rich– Modeling residence time



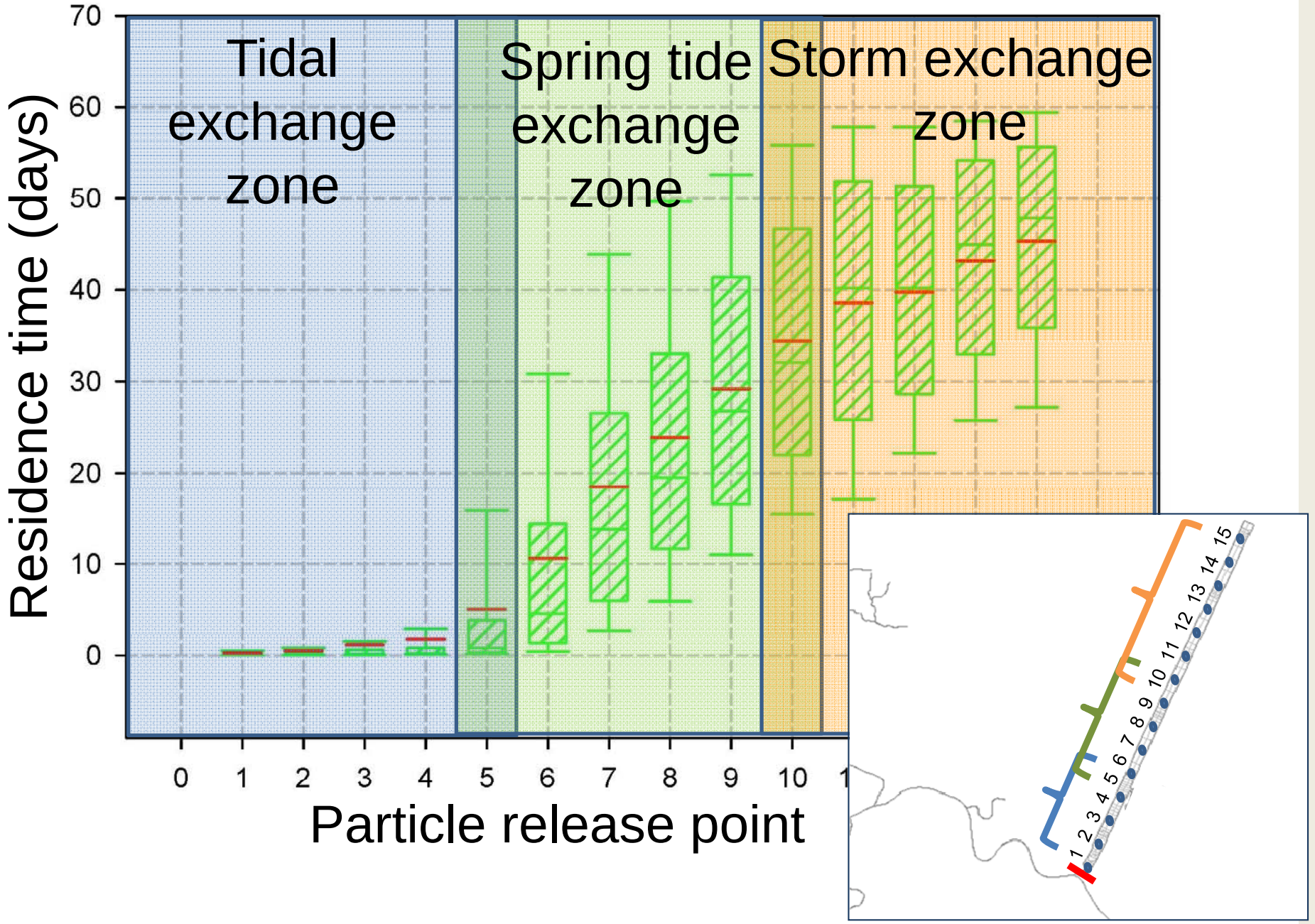
2. Delta was spatially gradient rich– Modeling residence time



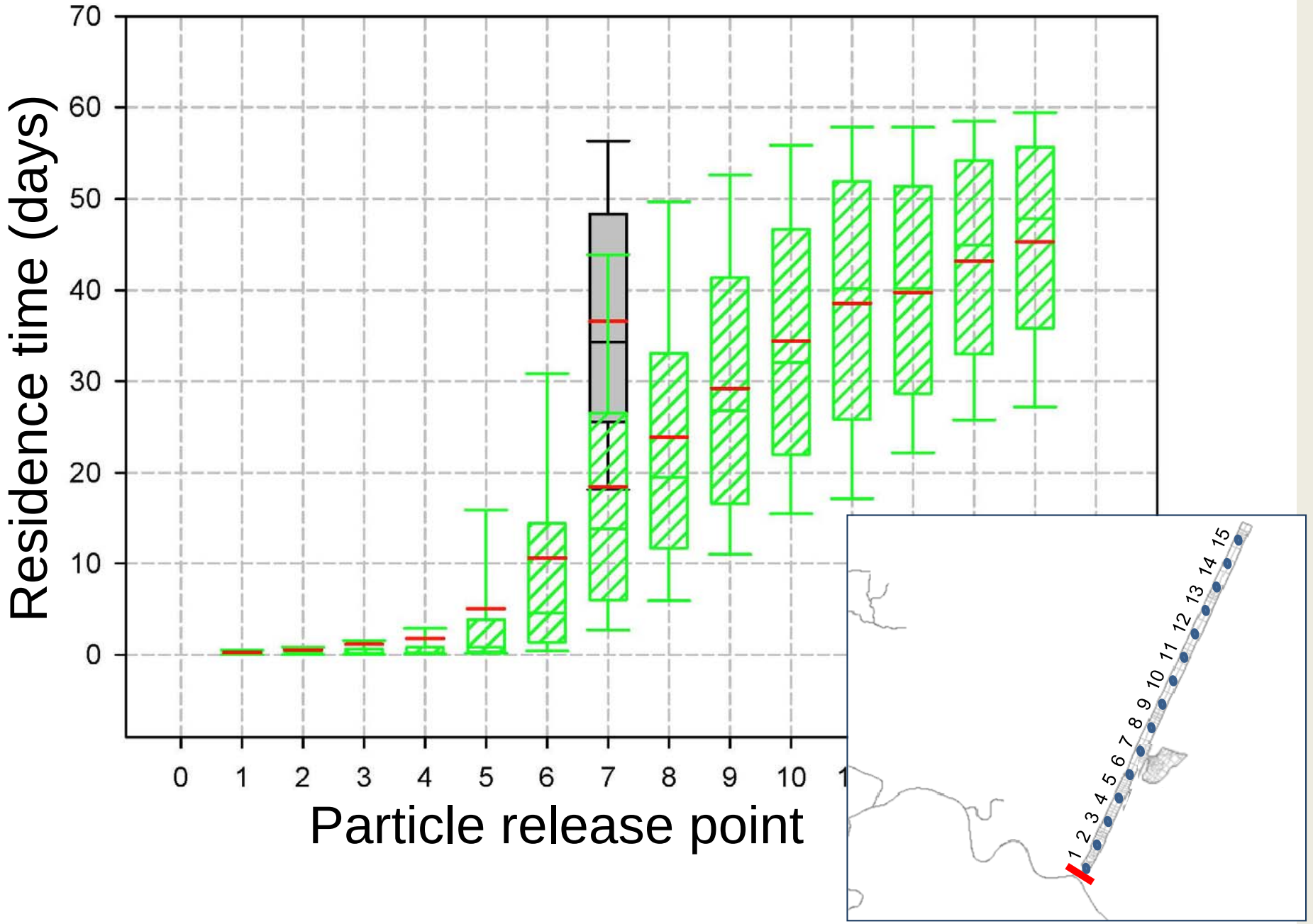
2. Delta was spatially gradient rich– Modeling residence time



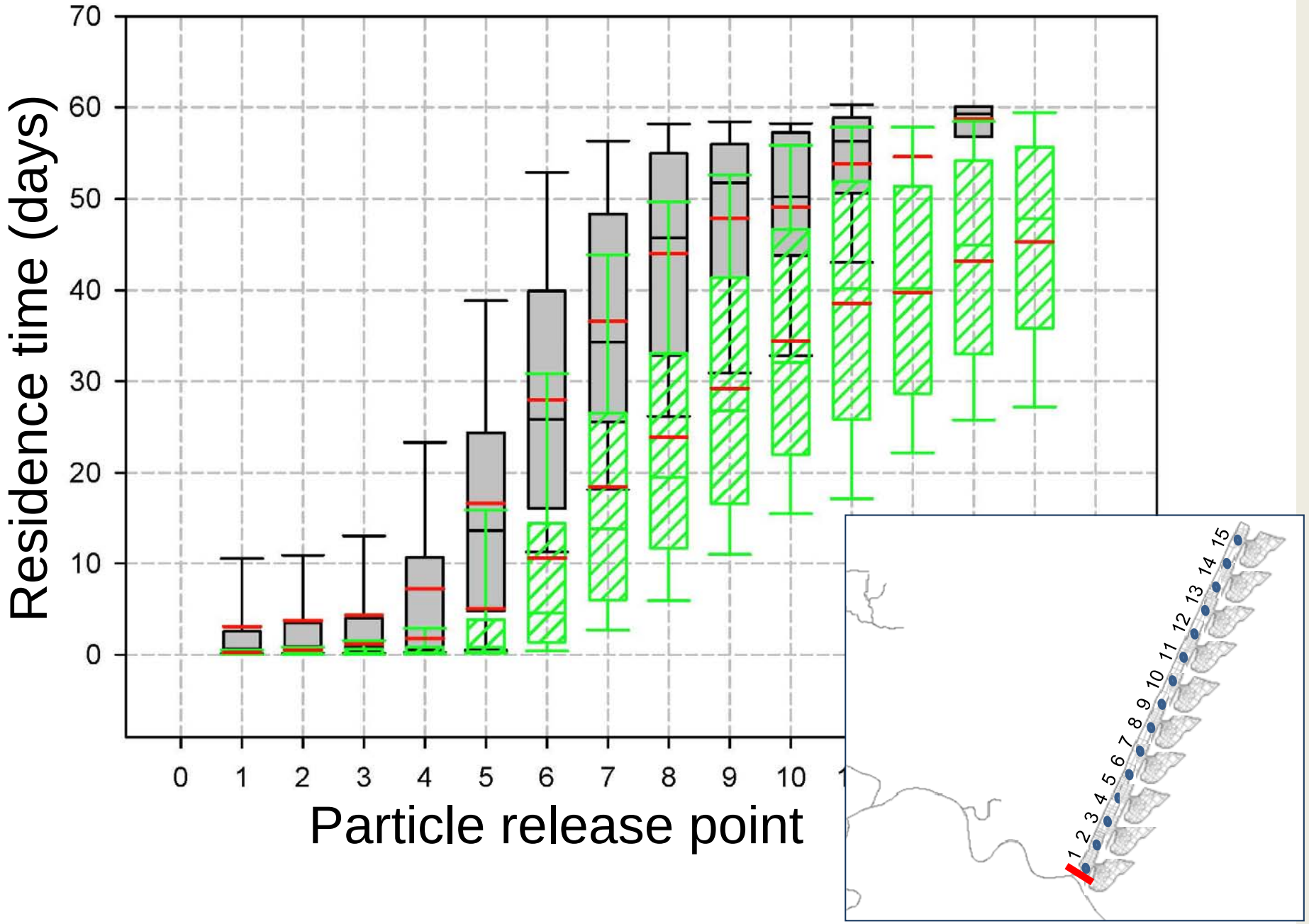
2. Delta was spatially gradient rich– Modeling residence time



2. Delta was spatially gradient rich– Modeling residence time

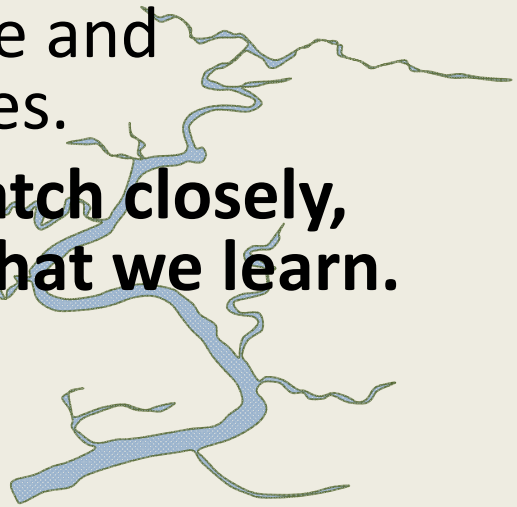


2. Delta was spatially gradient rich– Modeling residence time



Key ideas

- Historical Delta was narrower, longer, way more ecotone.
- Structural relationships produced a gradient rich system. *The distance to different was small.*
- Native species need multiple forage, refuge, and ontogeny options.
- Restored marshes should be productive and functionally accessible at multiple scales.
- **We know enough. Proceed boldly, watch closely, adapt when needed, teach the kids what we learn.**



Thank you

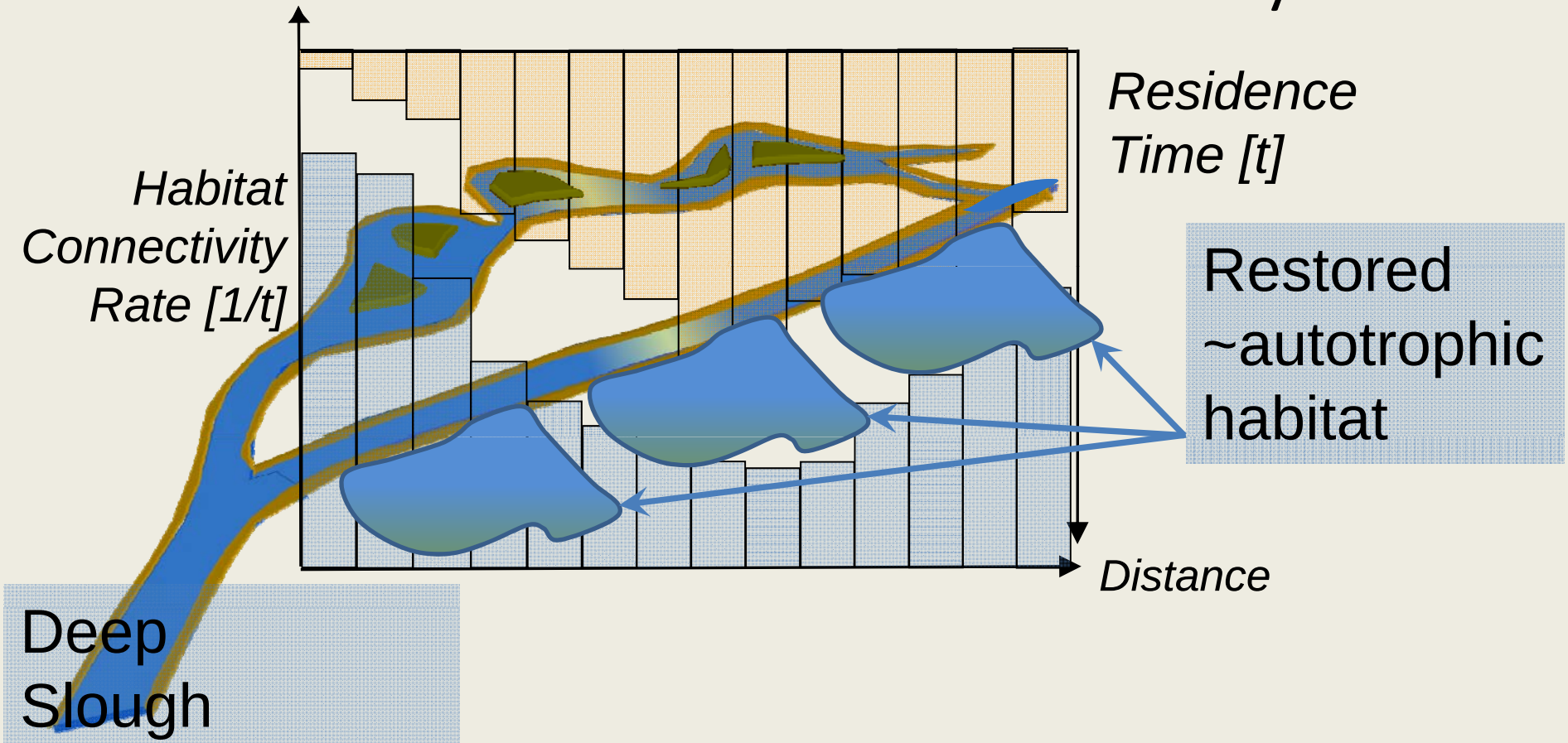
- Terri Fong, Stuart Seigel, Jon Burau, Steve Culberson, Cliff Dahm, Leo Winternitz, Dave Harlow, Curt Schmutte, Carl Wilcox, Matt Nobriga, Paul Massera, Katie Shulte Joung

4. Implications for restoration

- Use historical structure as energy/material conduits.

4. Implications for restoration

- Provide for variable habitat connectivity



Restored ~autotrophic habitat

Deep Slough (~heterotrophic habitat)

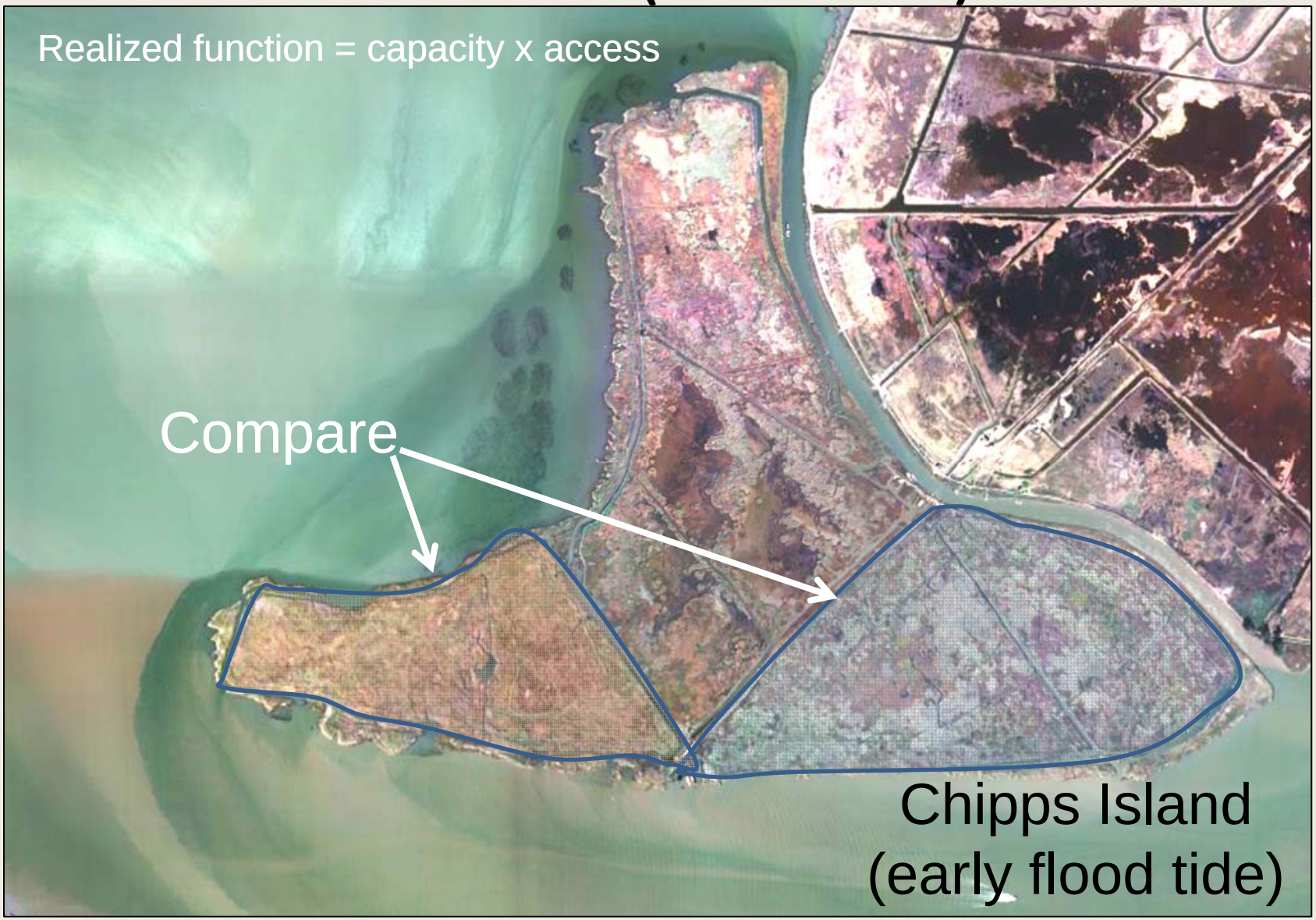
4. Implications for restoration

- Use natural processes to advantage:

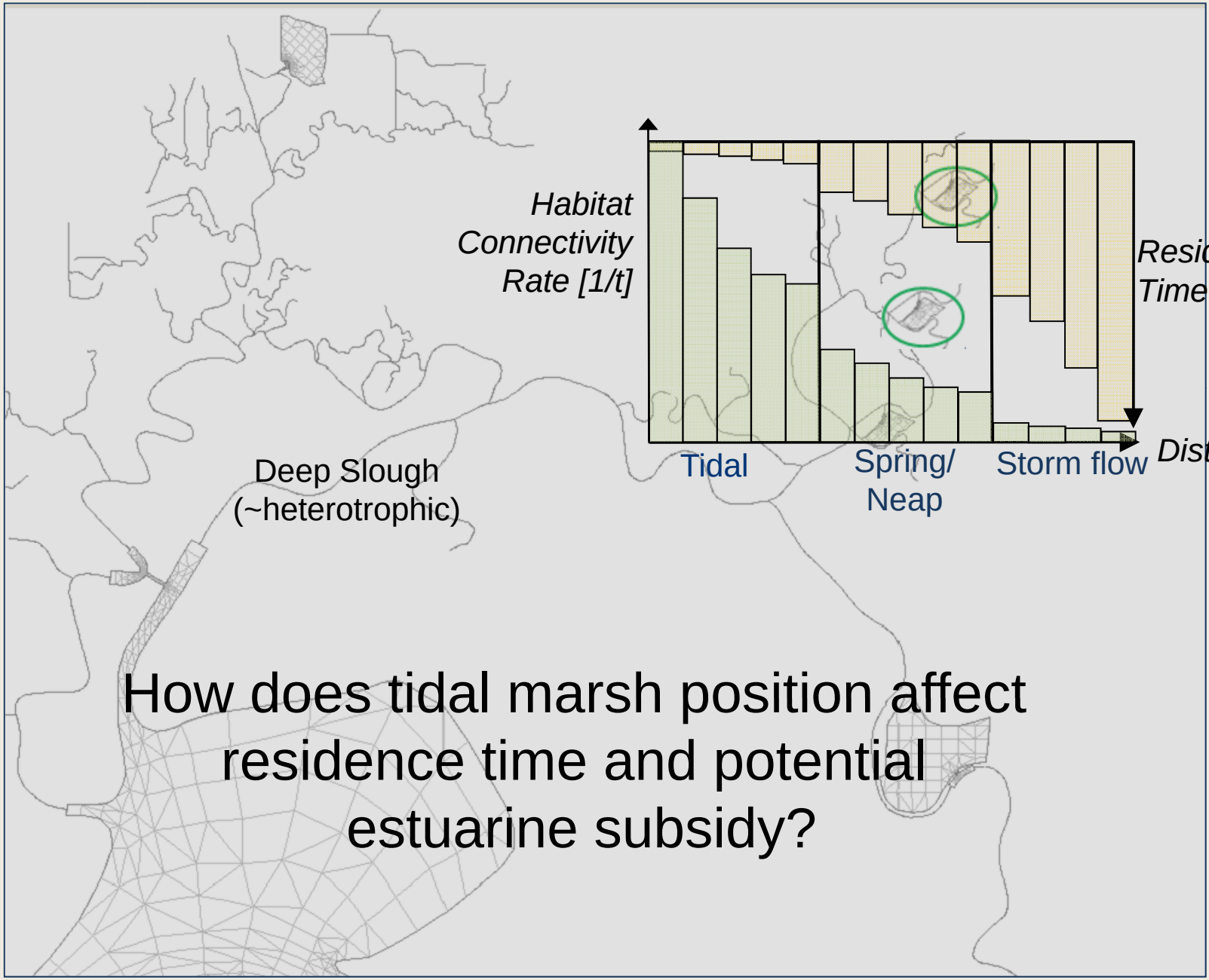
"Work with nature, let nature do the work"

Blacklock property (DWR)
Near end of ebb tide

3a. Structure and (realized) function



2. Delta was spatially gradient rich– Modeling residence time

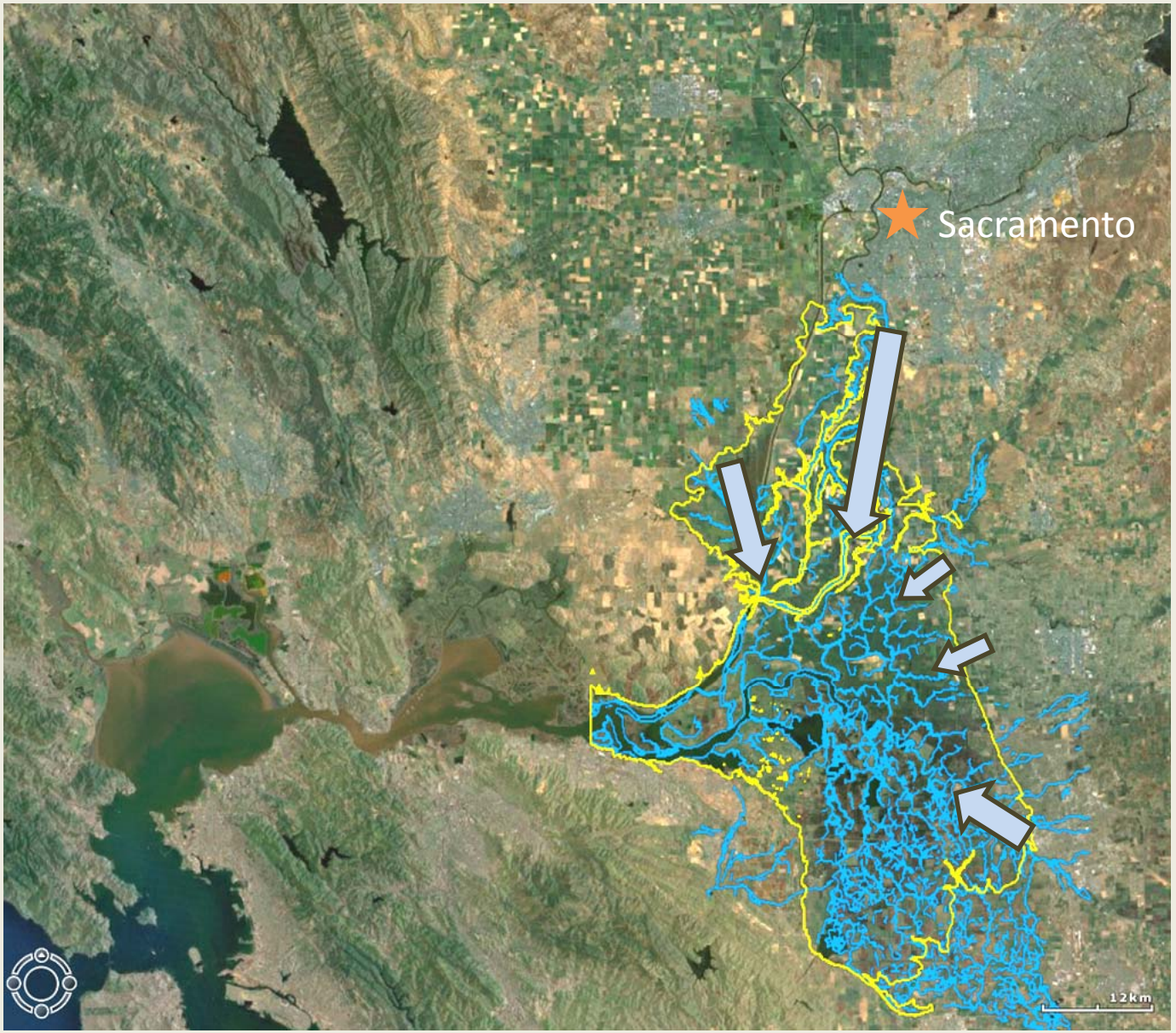


How does tidal marsh position affect residence time and potential estuarine subsidy?

1. Historical Delta was bigger *and* smaller

Historically, the tidal Delta scaled differently: bigger and smaller

Variable river influence penetrated deeper into the delta ("Five Deltas")
-Grossinger/Whipple



1. Historical Delta was bigger *and* smaller

Modern Delta is bigger *and* smaller

Modern Delta "bigger"

- ↑ geographical tidal extent
- ↑ bi-directional tidal area
- Longer tidal excursion
- Bigger tidal range
- Wider channels (canals)
- Long distance to different scalar concentration

Modern Delta "smaller"

- Levees "shortened" reach distances A to B
- Channel cuts short circuit transit A to B
- Lower channel/area ratio
- Short fish transit time

Hydrodynamics and transport processes on the historical landscape: geomorphic control of functional complexity and implications for restoration

Bay-Delta Science Conference 2010

Chris Enright

DWR and Delta Science Program

Hydrodynamics and transport processes on the historical landscape: **geomorphic control of functional complexity** and implications for restoration

Bay-Delta Science Conference 2010

Chris Enright

DWR and Delta Science Program

Hydrodynamics and transport processes on the historical landscape: geomorphic control of functional complexity and **implications for restoration**

Bay-Delta Science Conference 2010

Chris Enright

DWR and Delta Science Program